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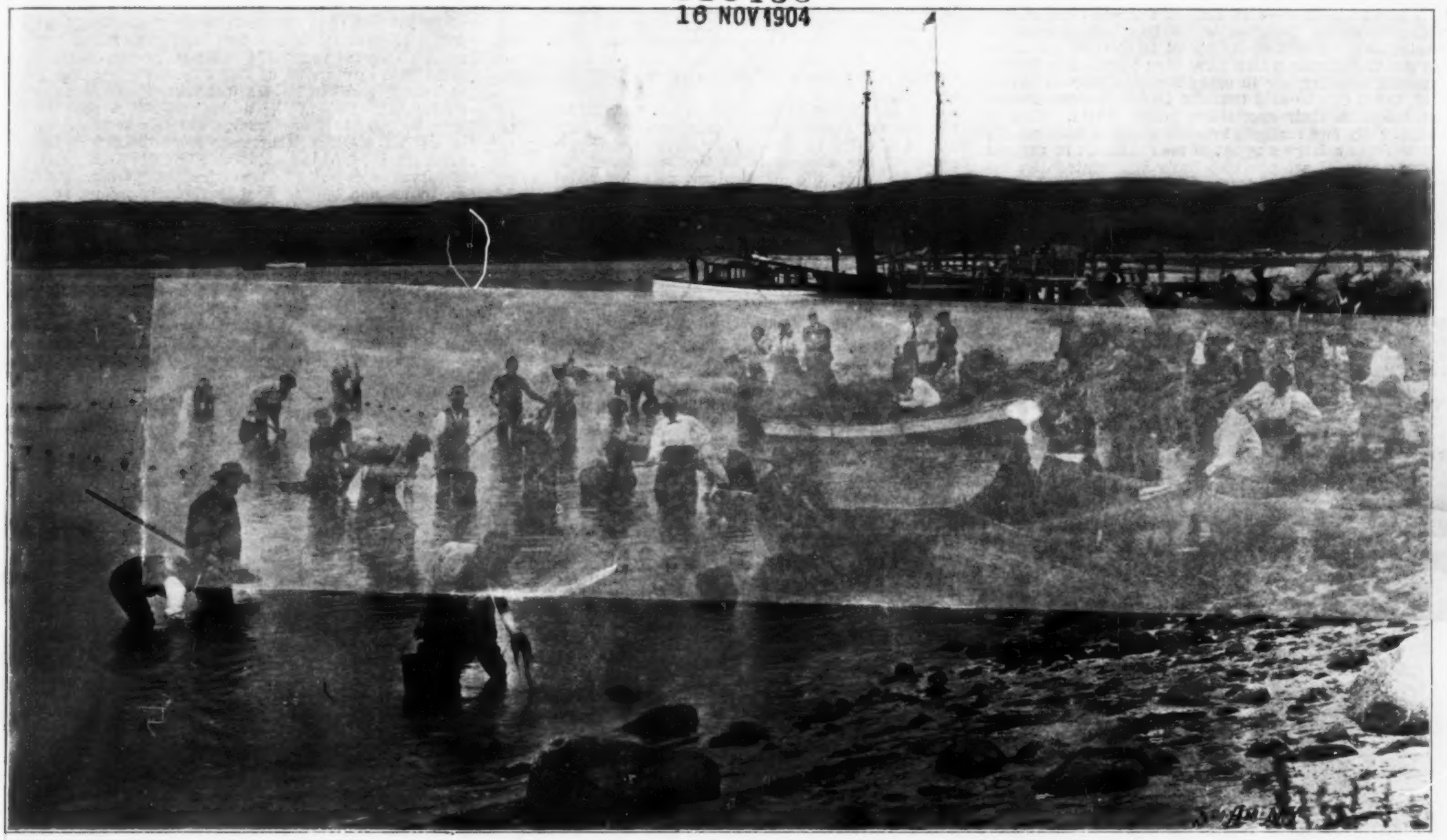
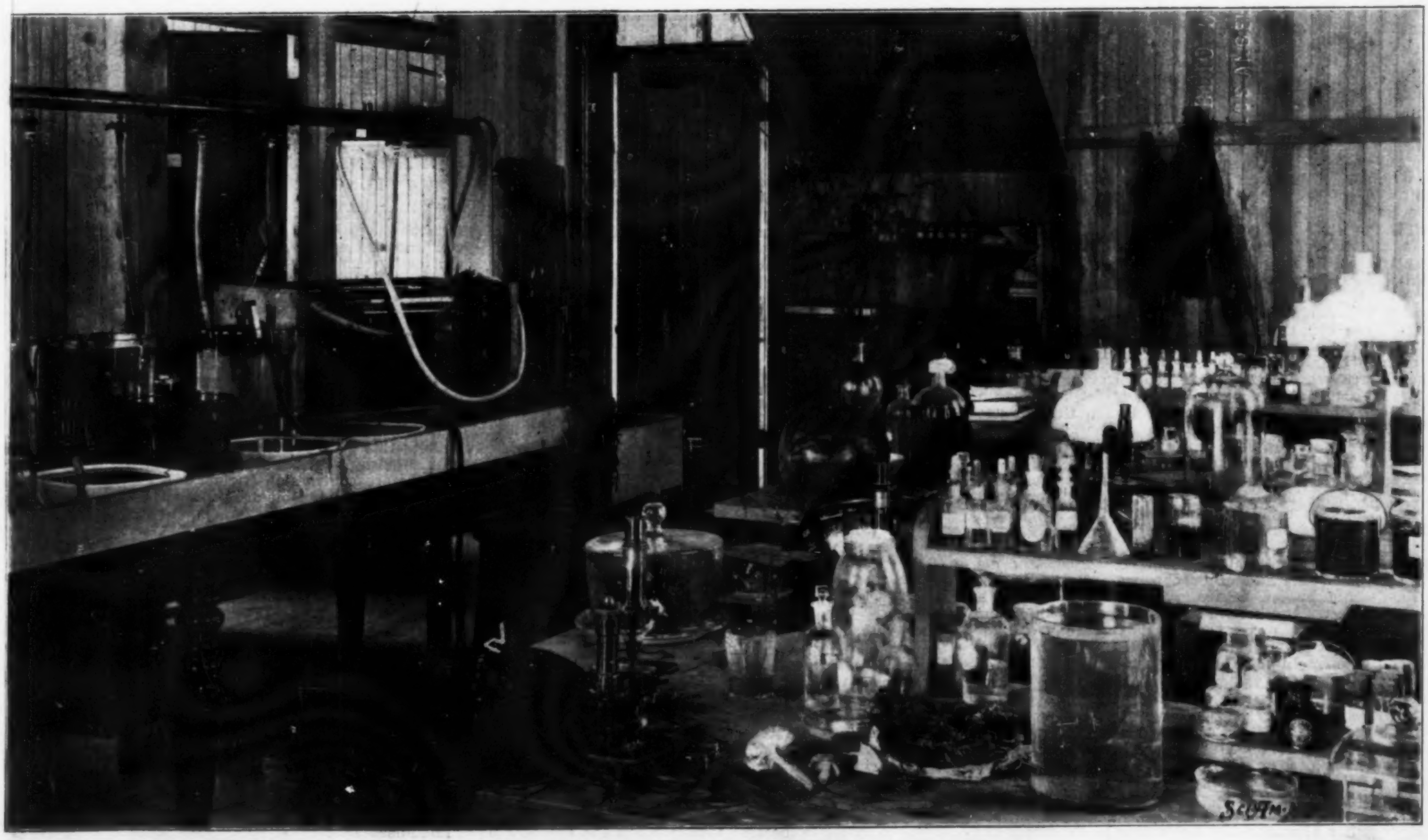


BIOLOGICAL STUDENTS GATHERING SPECIMENS.



A CORNER OF THE MARINE DEPARTMENT OF THE LABORATORY.

THE MARINE BIOLOGICAL LABORATORY AT WOOD'S HOLL, MASS.

THE BIOLOGICAL LABORATORY AT WOOD'S HOLL, MASS.*

By DAY ALLEN WILLEY.

THE Marine Biological Laboratory at Wood's Holl, Mass., has been appropriately termed a national center of instruction and research in every department of biology, for its faculty and students have truly endeavored to carry out the belief of Agassiz—that nature and not books should be studied. The institution is really a result of the teachings of the great naturalist. Had it not been for the laboratory which he established on Penikese Island in Buzzard's Bay, that at Wood's Holl would probably never have been in existence, for soon after the former was abandoned, the idea of a successor was agitated, although it was not until 1888 that the present institution was incorporated and opened for work. From a very small nucleus it has quickly developed until its membership in some years aggregates over 150 investigators and students from a wide range of American schools.

The laboratory does not belie its name, although it is a modest institution in appearance when contrasted with the stately building which has been erected at Naples as the result of European interest in the same study. The results which have been attained in Massachusetts, however, are in many respects fully as important, for it can be said that the instructors are among the ablest in their specialties in the world. This is undoubtedly one reason why each summer finds among the workers a large number of men eminent in various departments of science who have appreciated the opportunity given them for special study and research. Some of them received their degree years ago, but for the time become students with the rest, and the value of their experience benefits all who come in contact with them, while they aid the faculty not a little in the various investigations which are pursued. Of the fifty or more "investigators," as they are termed, to classify them from the regular students, some have already become noted in their particular field, but, as previously stated, have taken advantage of the broad opportunity which here exists to increase their fund of information.

The site was chosen after careful study of the New England and other sections of the Atlantic coast, it is perhaps the best in the country for the purpose, as hereabout the sea water is noted for its purity. The proximity to the Gulf Stream, which is [illegible]00 miles away, affords a chance to investigate the numerous varieties of animals and plants which the tide currents bring in from this river of the ocean. In the vicinity are also a number of salt marshes covered with water at high tide, as well as indentations in the shore where the bottoms are not only rocky, but consist of

A STEAMER USED BY THE STUDENTS.

sand as well as mud formations suited to the development of a variety of forms of life found in shallow water. In this section of Massachusetts are numbers of small ponds and lakes of fresh water where other species of plant and animal existence can be easily obtained. The advantages of the place have been appreciated by the government, which, as is well known, has here located one of the principal stations of the United States Fish Commission. It may be said that the vessels on duty at the station as well as other facilities have been generously placed at the service of the laboratory and have proved of great value.

The institution despite its limited resources has really accomplished remarkable results. The main building is a cheap structure of wood devoted to the various laboratory departments. This and two or three small buildings are all that have thus far been erected, and it is an actual fact that with the chemical apparatus, boats, etc., the entire value of the property is not over $35,000—far less than some of the single small buildings connected with American colleges. During the sixteen years of its existence, however, the laboratory has attained such a place in scientific research that one noted writer has given it the title of the "biological clearing house of the country;" and such it is in fact, for here have been made discoveries which have attracted worldwide attention among scientific investigators. One of the most notable was that of Prof. Loeb, when he found that by treating the unfertilized eggs of the sea urchin with certain solutions of salt, they could be developed into normal larvæ. His success in this experiment really created a new era in biology. Following the lines of his observation came the trials of salt and other chemical solutions upon animals and human beings, which have had such a notable effect. Another line of investigation which has been attended with great success is the study of "cell lineage," as it is termed, which originated in the laboratory. The tracing of what are known as the cleavage cells through their various developments has thrown additional light upon the growth of organs of various animals. This study has been very exhaustively pursued since it was first taken up, and has been of much value especially to the medical profession. Physiological morphology is another branch which has interested many of the students, while some very curious results have been attained by experimenting with not only marine animals, but insects. For example, the grafting together of moths and butterflies in the pupæ has been successfully accomplished, and a new creature brought to life. These and numerous other experiments have led to discoveries in biology which might never have been known had the facilities not been at hand for the examination of so many forms of growth in their several stages of development.

One of the most interesting features of the routine is the gathering of specimens. Almost daily in summer expeditions start for various points noted for their abundance and variety of specimens. Small seines, dip nets, shovels, and other implements are used by the energetic workers, and even the women students, who represent an important contingent of the summer school, do not hesitate to search the beaches and rocks for their prey with the men. Pails and jars are provided for the creatures which must be kept alive in the water, and each boat usually has a receptacle for the many marine plants which are gathered, as well as shell fish and insects. The laboratory is provided with aquaria, where specimens can be kept until it is desired to experiment with them, the water being replenished daily. As already stated, the vessels of the Fish Commission, which are usually sent to this station each summer, are placed at the disposal of the instructors and students when not performing other duties, and thus they are enabled to secure material by deep-sea dredging and from the depths of the Gulf Stream itself.

The abundance of material provides opportunity for the study of zoology, embryology, and botany especially, but in addition to these, physiology is also pursued by many of the attendants at the laboratory, and it is probable that the curriculum will be considerably broadened in the near future. The laboratory is at present in charge of Prof. C. O. Whitman, one of the most enthusiastic disciples of Agassiz, who has been closely identified with it since its inception, and is in a great measure responsible for what it has accomplished.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

A NEW GERMAN MICROSCOPE.

A DISCOVERY which may have far-reaching results in the field of scientific investigation and do much toward the further solution of the problem of the molecular construction of matter was recently made by two professors of Jena University—H. Siedentopf and R. Zsigmondy. They have discovered a new method of microscopic observation, whereby ultramicroscopic particles are not only made visible, but can also be studied with a view of determining their size. A full description was recently published by the inventors in the German scientific journal Annalen der Physik (volume 10, 1903), and reprints of the same are to be had by interested parties by addressing the men above named.

The method consists mainly in a powerful artificial illumination of the particles to be observed. These particles, because of their minuteness, exert no material influence upon the vibratory period of the light waves, and hence appear to the observer as self-illuminating, or luminous objects, by virtue of their reflected light. Since, however, the reflected light is weaker than the original illuminating beam, it is necessary, in order to secure the advantages of an intensified illumination of the particles, to employ the principle of dark-field illumination.

Heretofore, the great imperfection in the method of dark-field illumination has been the failure to eliminate all light reflected from the surfaces of the condensing lens and the microscopic objective. Whenever any of the light of the stronger illuminatory ray mingles with the weaker light reflected from the particle which is being observed, the visibility of that particle is proportionately blurred, just as the light of the rising sun gradually obscures a morning moon. Perfection in dark-field illumination has been attained when none of the light of the illuminatory ray enters the line of vision in the observation of an object through the microscopic objective, and the object is visible solely by virtue of its own reflected light.

This interference of the direct light of the illuminatory ray or of its reflected light from the surfaces of the condensing lens, with the reflected light of the object under observation, is overcome through the application of the principle that when the illuminatory ray is perpendicular to the axis of the microscopic objective any direct light or any light reflected from the surfaces of the condensing lens can no longer enter the line of vision of the observer, and hence can no longer interfere with the reflected light of the particle to be observed; provided that the condensing lens for the illumination of the object and the microscopic objective for the observation of the object are so adjusted as to meet at a common focus A (Fig. 1). It

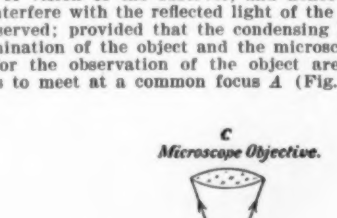


FIG. 1.

will be seen that with this construction no light reflected from the condensing lens B, or passing through it directly, can possibly enter the microscopic objective C, thereby permitting the observer of the particle located at A to view the same solely by virtue of its own reflected light. This method of dark-field illumination enables the employment of the most powerful sources of illumination for microscopic observation, and for this reason must be considered as a marked advance in the technique of this field.

The principle involved in this new method is well illustrated by the common phenomena of the "visible sunbeam" in a darkened room which is penetrated by a ray of light. Dust particles in the path of the ray, hitherto invisible, become visible when the eye of the observer is at right angles to the direction of the penetrating ray. If, now, the illumination is strengthened through the employment of a more powerful source of light and a condensing lens, and the power of the eye is strengthened by means of a microscopic objective, we have all the essentials of the new method of dark-field illumination, as employed by the two Jena professors for rendering visible ultramicroscopic particles.

The figure given below represents an outline drawing of the new illuminating apparatus, reduced to one-tenth of its actual size. It is constructed as follows: By means of a clock heliostat, a ray of light is sent through an iris screen into the dark observation chamber within which is placed the apparatus. The various individual movable parts of the instrument are carefully and accurately mounted upon a metal slide P by means of delicately adjustable riders. The beam of light cast into the dark chamber by the heliostat first strikes the telescopic objective F_1. This lens has a diameter of 100 millimeters (3.94 inches) and condenses the ray so that it measures but 1 millimeter (0.03937 inch) on striking the apparatus S which contains an accurately adjustable slit. The size of this slit may be varied, at pleasure, from 5 millimeters (0.19685 inch) to 0.5 millimeter (0.01968 inch) in width (horizontal dimension), and from 0.1 to 2 millimeters (0.00398 to 0.07874 inch) in height (vertical dimension). By virtue of this adjustable slit, the beam of light is made to lie flat, its greatest dimension being horizontal. Behind the adjustable slit a polarizer N may be placed, if necessary. The iris screen J serves to cut off all light that may arise through reflection from the sides of the adjustable slit S. Another screen B serves to cut off the lower half of the beam, in case an immersion lens is used in the microscope, so as to prevent the intrusion of injurious reflections that may arise in this case. A second telescopic objective F_2, of a diameter of 80 millimeters (3.15 inches), reduces the size of the flattened beam by one-fourth. This reduced beam is again reduced to one-ninth its size by the microscopic lens in the condenser K, and in that form strikes the object which is being observed through the microscope A. In order that the flattened and reduced ray may come to a focus in line with the axis of the examining microscope, the condenser K is fitted with sensitive micrometer screws, working at right angles to each other.

By means of this apparatus, the Jena professors have seemingly accomplished what the great Helm-

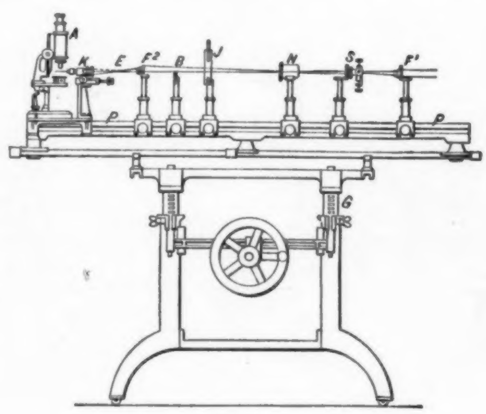


FIG. 2.

holz did not conceive as possible. This physicist declared the limit of microscopic perception to be 0.0001 millimeter (0.000003937 inch), while it is estimated that this limit has been extended to from 0.000004 to 0.000007 millimeter. That such an achievement promises great things in scientific investigation is readily seen.

INDEPENDENCE OF CLOSELY CONNECTED FUNCTIONS OF MUSCLE FIBER.

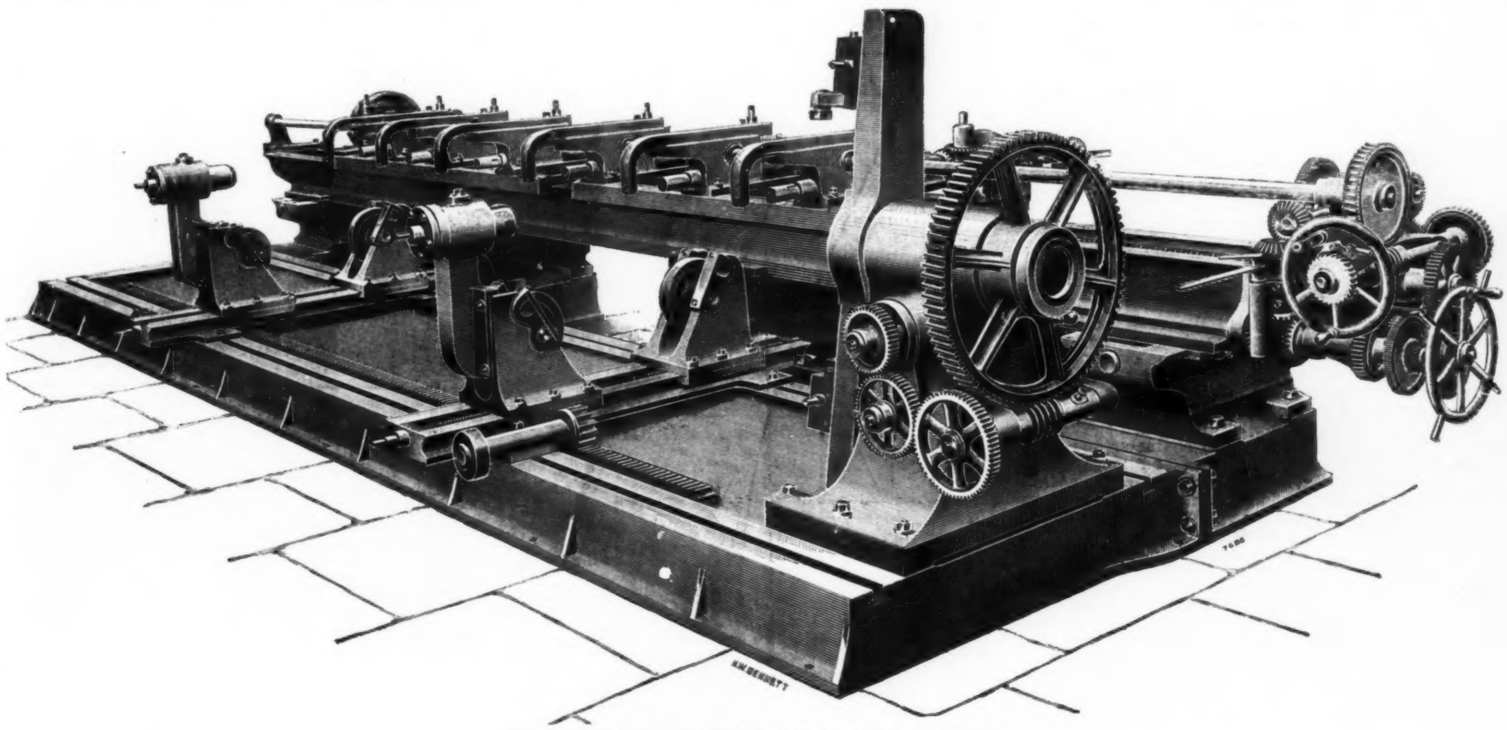
THE movement of a muscle depends on the simultaneous operation of three functional properties of its constituent elements, i. e., excitability, conductibility, and contractibility. By the first of these, says T. W. Engelmann in Archives Néerlandaises, is meant the faculty of such an element when excited of becoming active, which is indicated by the appearance of electric currents (action currents), and followed, after a short interval, during which the energy remains latent, by the mechanical process of contraction. Excitability is measured by the inverse ratio of the value of the most feeble excitation sufficing to produce a perceptible irritation, i. e., the inverse of the threshold value (Schwellenwerth). Under normal circumstances this process of activity or of irritation is communicated by waves to neighboring muscle constituents even before contraction begins, and extends as far as there exists a physiological contact between such excitable muscle constituents or elements. The measure of conductibility is given by the velocity which characterizes the process of inter-communication, while contractibility, finally, is measured by its mechanical equivalent. Notwithstanding the close connection between these functions referred to, however, they are, up to a certain point, independent of each other, and, under certain conditions, one of them may be entirely suspended while the others remain in full activity. The author describes as *bathmotropic* (from βαθμος = threshold) such influences as affect excitability, as *dromotropic* such as interfere with conductibility, and as *inotropic* such as lessen or destroy contractibility. The independence especially of conductibility is very striking, and has been known for a long time. Thus under certain circumstances, for instance, owing to the stoppage of circulation, conductibility may be reduced in the muscle fibers to zero, and yet a direct and primary act of an excitant may still provoke powerful "idiomuscular contractions." As a case in point it may be stated that water, as was discovered by W. Biedermann, may destroy entirely, or nearly so, the

contractibility of an ordinary muscle (Sartorius) without producing any perceptible bathmotropic or dromotropic effect. The author, who has experimentally studied especially bathmotropic influence, exercised both upon ordinary striated muscles, which are under the control of the will, and upon ventricles and auricles, and has already published some of the facts discovered by him, adds in this paper some new data. Thus he points out that when the commencement of a portion of the sartorius of a frog was inoculated with curare, after this portion had been dilated in water and deprived of its contractibility, without having lost either its excitability or conductibility, the threshold of excitation (Reizschwelle) was often not sensibly diminished.

Experiments made with reference to the heart showed similar results. In many such cases the velocity of transmission of the motive power in a portion of the sartorius or in the heart, which had been deprived of contractibility, was not diminished and occasionally was even increased, thus producing a positive dromotropic effect side by side with a negative inotropic effect. Nuel discovered that the action of the vagus not only diminishes the frequency of the cardiac contractions, but also the intensity of the systoles. Schiff and Eckhard, and, more recently, McWilliam and W. Mills, have demonstrated that excitation of the pneumogastric causes the ventricles and auricles to lose their direct excitability by means of electricity. The author's experiments have confirmed this fact in so far as they have shown that the heart, or at least its auricle, can be made to remain for a very short time passive to electrical or mechanical excitation by a strong excitation of the pneumogastric, but he maintains that the excitability of the auricle very soon returns to its normal condition—in fact, long before the diminution or total stoppage of its contractibility has ceased. The new facts discovered by the author confirm, in his opinion, his theory that the physiological process of irritation indicated by the so-called "action-currents," is linked to other constituents of the muscle than the mechanical process of contraction; otherwise their independence of each other would be incomprehensible. The question therefore arises whether the microscope may reveal to us the difference of these hypothetical constituents, or whether their difference lies beyond our limits of visual perception. The author has elsewhere (Archives Néerlandaises, (1) 27, 65, 1893), stated his reasons for assuming that the physiological effect indicated by the appearance of electric currents is linked to the birefringent portions of muscle fiber, while the mechanical effect of contractibility is linked to the monorefringent portions, and thinks that the result of his recent experiments strengthens his theory. G. G.

SIX-SPINDLE MULTIPLE DRILLING MACHINE.

WE illustrate a six-spindle multiple drilling machine, recently constructed by Messrs. Hulse & Co., Limited, of the Ordsal Works, Manchester, for drilling the steam-drums of a patent water-tube boiler which has just been placed on the market. The machine is capable of drilling the holes for the circumferential seams and butt-strips of steam-drums from 2 feet to 5 feet in diameter and 12 feet to 25 feet long. As will be seen, the drill spindles are horizontal, and the drum to be drilled is also chucked in the horizontal position. The main longitudinal bed on which the drill carriages slide is mounted upon short transverse beds, being adjustable on these to suit the varying diameters to be dealt with. Upon the longitudinal bed are mounted two horizontal slides, which are each independently adjustable by screw gear, and are provided with a dividing mechanism for drilling butt strips, which mechanism can be worked independently either by hand or power. Upon each slide are grouped three drilling headstocks, but all six may be placed upon one or the other slide, or otherwise grouped at will. The six drilling headstocks are each independently adjustable on the horizontal slides to varying distances apart by means of racks and pinions, and are each fitted with a steel spindle rotating in a sleeve forming an accurate guide for "pitch" drilling, the variable self-acting feed motion being arranged so that it may be applied to or suspended from the spindles either collectively or independently. Each drilling headstock is fitted with an overhanging bracket for supporting the outer end of the drills, which steadies the drill when cutting, and prevents breakage of drills. The apparatus for supporting the work consists of two roller stays, each having three rollers, the stays being mounted on short transverse slide beds, which are adjustable along a base plate by rack and pinion, so as to suit the various lengths of drums. The drum is rotated and divided by a headstock with a balanced duplex arm fitted with worm and wheel, and with a dividing plate for circumferential seam drilling. The machine above described has been supplied to a leading firm of boilermakers, who have taken up the manufacture of a patent water-tube boiler.—Engineering.



SIX-SPINDLE MULTIPLE DRILLING MACHINE.

A SIMPLE EMULSION FOR MATT OR PRINTING OUT PAPER.

By A. J. JARMAN.

SINCE the introduction of platinotype the popularity of matt surface photographic printing papers has been largely augmented. The public taste for prints made upon matt surface paper has taken many years to educate. Not many years ago the majority of the photographer's patrons would accept nothing but highly glazed prints, while to-day the demand is almost entirely for matt surface portraits. Strange as it may appear, no one ever asked for or expected to see a steel engraving upon a glossy surface, no matter what that engraving represented. The matt surface engraving was always admired for its beautiful and artistic rendering of anything and everything that it represented, and yet the demand held sway for a glossy surface for any print made by photography.

Whenever a matt surface was required for a portrait the usual plan was to sensitize a sheet of albumenized paper upon the silver solution by floating it upon the back of the sheet instead of the glossy face. This plan answered well; the only drawback was that the grain of the paper was of a coarser character upon the back, so that for small portraits this grain was a little too pronounced.

Many photographers who had facilities would prepare a specially salted paper for portraits that were to be colored, and in this way overcome the objection of sensitizing albumen paper upon the back. Nearly every photographer had his pet formula, and guarded it with such care that he would trust no one to prepare the paper with its salting solution except himself. It is a well-known fact to-day that one of the very best surfaces to work upon for coloring in watercolor is the carbon print. Apart from its absolute permanency as a base, the surface possesses the right tooth for the adhering of the pigment. It is just such a surface as this that is required upon other prints than carbon, both for finished matt surfaces and for the purposes of coloring. The way to obtain this surface upon almost any kind of paper, and to print it out so that the correct depth is ascertained on sight, will be here described, and anyone desirous of preparing special paper for his own use will be enabled to do so. Some of the crayon drawing-papers can be utilized, as well as many other plain photographic papers that may meet the desires of the photographer. If a glossy paper is desired, the emulsion should be coated on a baryta-coated stock.

There will be required, in the first place, two half-gallon stoneware crocks with lids. The best shape to employ is a crock with the sides running straight, with no depressed ridge at the top. One of these crocks is for the preparation of the emulsion, the other to receive the emulsion when filtered. An enameled iron saucepan of about two gallons capacity will be required, in which to stand the crock for preparing the emulsion, and also to remelt the emulsion after it has become set. The following is the formula for the emulsion, which must be prepared and mixed in the order given. Failure will be impossible if these details are scrupulously attended to.

Having procured two half-gallon stoneware crocks with lids, clean them out well with hot and cold water, and place into one of these the following:

Distilled Water	10 ounces
Gelatine (Heinrich's, hard)	4 ounces

Cut the gelatine into shreds with a clean pair of scissors. Press these shreds beneath the water with a clean strip of glass and allow to soak for one hour. Now proceed to melt the water-soaked gelatine by placing the crock into hot water in the enameled saucepan, the water standing about half-way up on the outside of the crock. Bring the water to boiling-point, and keep the gelatine occasionally stirred until it is completely dissolved. Then remove the crock to allow the contents to cool down to 120 deg. F. Now prepare the following which can be done while the gelatine is melting.

No. 1.	
Rochelle Salts	90 grains
Distilled Water	1 ounce
No. 2.	
Chloride of Ammonium	45 grains
Distilled Water	1 ounce
No. 3.	
Nitrate of Silver	1 ounce and 75 grains
Citric Acid (crushed crystals)	95 grains
Distilled Water	10 ounces
No. 4.	
Powdered White Alum	90 grains
Distilled Water (hot)	5 ounces

The latter solution may be made with boiling water. When these solutions are prepared, pour into the hot gelatine solution No. 1, stirring all the while with a clean glass rod. Then add No. 2. Rinse the vessel with a little distilled water, and add to the gelatine. Now, while stirring gradually add No. 3, and lastly add No. 4, which may be very hot. This will cause a decided change in the color of the emulsion. Lastly add two ounces of pure alcohol (photographic). This must be added very gradually with vigorous stirring, because if added too quickly it will coagulate the gelatine and form insoluble lumps. The emulsion must, of course, be mixed under a light not stronger than an ordinary small gas-jet, or under a yellow light obtained by covering the windows with yellow paper. The cover may now be placed upon the crock, and the emulsion put aside for two or three days to ripen.

At the end of this time the contents of the crock, now formed into a stiff emulsion, may be remelted in hot water by placing the crock in the enameled saucepan over a gas stove. The emulsion may be broken up by cutting it with a clean bone or hard-rubber paper cutter to facilitate the melting. Stir the mixture occasionally until thoroughly dissolved, and add the following as soon as the emulsion has reached a temperature of about 150 deg. F.:

Distilled water	4 ounces
Pure alcohol	1 ounce

The emulsion must now be filtered into the second crock. The filtering is best accomplished in the following manner: Take an ordinary plain-top kerosene lamp chimney, tie over the small end two thicknesses of washed cheese-cloth. Invert the chimney, and insert a tuft of absorbent cotton about the size of an ordinary egg. Press it carefully down upon the cheesecloth. Fix the chimney in the ring of a retort stand (or cut a hole about three inches in diameter in a wooden shelf), so that the crock may stand conveniently beneath. In the chimney place a strip of glass, resting upon the cotton, to prevent the cotton from lifting. Now pour in the hot emulsion and allow the whole of it to filter through the absorbent cotton. This accomplished, we are now ready for coating the paper, which is best done in the following manner:

Cut the paper into strips or sheets, say, twelve

inches wide and the full length of the sheet. This will be, let us suppose, 12 x 26 inches. Attach, by means of the well-known photographic clips, a strip of wood at each end of the paper upon the back. Three clips at each end will be required. Having a number of sheets thus prepared, the emulsion should be poured into a porcelain pan or tray, kept hot by standing within another tray containing hot water. The emulsion tray being, say, 11 x 14 size, the paper now is easily coated by holding the clipped ends in each hand, then holding the left end of the paper up, and the right-hand end lowered, so that the curve of the paper just touches the emulsion. Then raise the right hand, at the same time lowering the left hand at the same rate. Then lower the right hand, lifting the left. Repeat this operation once more; then drain the excess of emulsion at one corner of the tray, say, the left-hand corner. Just as soon as the emulsion has drained, the coated sheet of paper may be hung up to dry, by the hooks attached to the clips, upon a piece of copper wire stretched from side to side of a spare closet or room that can be kept darkened until the paper is dry. In this way coat as much paper as may be required. When it is dry it may be rolled up tight or kept flat under pressure until needed.

If any emulsion remains, it may be kept in a cool place for two weeks, and still be good for coating. Be sure to clean out all the vessels used before the emulsion sets, otherwise this will present a difficult task, since the emulsion sets into an almost insoluble condition.

This emulsion is so made that it does not require to be washed. If it is washed it will become spoiled. It is easy to make and easy to use. If it is desired that only small sheets of paper are to be coated, they may be floated on the emulsion, but in this case the paper must be damp, which is easily accomplished by wetting a sheet of blotting-paper, then covering this with two dry sheets of blotting-paper. Place the sheets to be coated upon these, and place under pressure during the night. Next day they will be in good condition for floating.

When the coated paper is dry, it may be printed and toned just the same as any other printing-out paper, with any toning bath, and fixed in hyposulphite of soda as usual. Toning may be carried to a rich blue-black, or if not carried too far will remain a beautiful sepia color. After well washing and drying it will be observed that the surface corresponds with that of a carbon print; if the paper has been of a somewhat absorbent character, the surface will be entirely matt, and will give an excellent tooth for coloring or finishing in sepia, black and white, etc.—Wilson's Photographic Magazine.

SUGGESTIVE OUTLINES OF A DYNAMIC EXPLANATION OF CHEMICAL PHENOMENA.

By FRANK A. HEALY.

AN inspection of the chemical elements arranged in the order of their atomic weights shows such remarkable periodicity and inter-relation of the members that one is naturally led to speculate upon the question of their origin as being evolved in some manner from the lowest term or its antecedent.

In this arrangement of the elements each succeeding member shows a certain change of character and properties, becoming successively more and more acidic until a point is reached where an abrupt change takes place and a strongly basic element follows. If lines of division are made between the strongly acid haloid and the strongly basic univalent alkali metal, a number of series is formed, in each of which the elements pass from a basic metallic state to a non-metallic acid state. On observing the number of elements in each it is seen that the series occur in pairs. The lithium-fluorine series contains seven members, so likewise does the following sodium-chlorine series. The next two have seventeen each. After them comes one beginning with caesium which, while incomplete, shows strong evidence of having a greater number than those it follows. Of the next series, however, but two are known with certainty, thorium and uranium, having the highest known atomic weights.

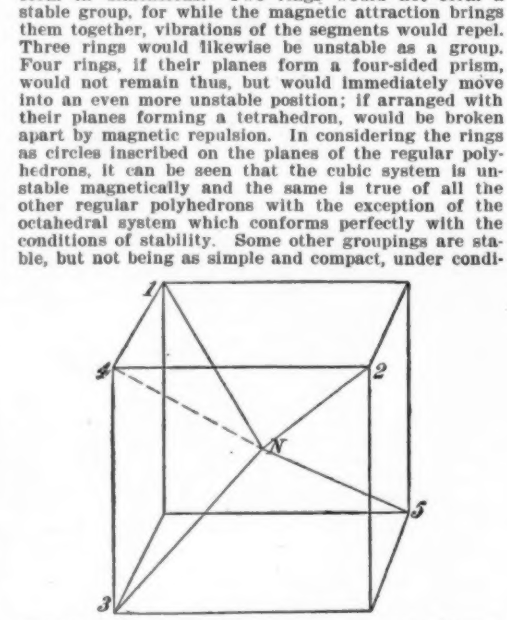
The first two series of seven are not complete with that number, but appear to have an inert gaseous nonvalent element as the first (and last) member. The atomic weight of helium is given as 4 coming before lithium, or neon 20, being after fluorine and before sodium. That of argon is 39.9, considerably higher than its place in the periodic table would require. The discrepancy has been explained as being due to slight admixture of similar elements of higher atomic weight, such as krypton, to which is assigned the atomic weight 82, coming between bromine and rubidium, and forming the connecting link between the potassium-bromine and the rubidium-iodine series; xenon is also found in the atmospheric gases and the atomic weight (128) given it, places it between iodine and caesium.

The series beginning with sodium is often taken as being the most typical of the series. If we include argon in it, there are eight members. As the valency rises regularly by one unit to each succeeding element, and chlorine, the seventh member, has a valency of seven, we might conjecture that, could the valency of the eighth term, argon, be made manifest in chemical combination, it would be octavalent. The chemically inert gases manifest no valency and as they come between elements which exhibit univalence, they are in harmony with the regularity of the system. In the three long series, the first few members and the last ones adhere most closely to the regularity of the typical series; the intervening members show peculiar variations.

The whole periodic system is strongly suggestive of evolution by some kind of additions from the lowest term or its antecedent whereby the eighth addition brings the atom to a condition similar to the first. Evidence has been produced by different investigators, notably Sir Norman Lockyer, giving indications of evolution of the chemical atom. After many fruitless efforts to obtain more light on the problem which chemical phenomena present, a simple conception or assumption was finally discovered which, when developed logically, afforded results that show a remarkable parallelism with a great deal of the phenomena of chemistry, physics and biology. While the system thus developed from a simple but arbitrary assumption may come far from being in perfect accordance with the actual reality, yet, by its extensive analogy to actual observed facts we may be brought a step nearer the solution of the problems of matter by its suggestive value.

Imagine a portion of space devoid of ordinary matter. Into this space elastic ring-shaped formations are produced or brought, moving about with great velocity. Suppose, also, that an electric current flows in the ring substance without resistance or that the current is constantly maintained. This is the assumption simply, an elastic current-bearing ring, and from it can be evolved a system having great similarity to the material system with which we are acquainted.

It can be shown that these rings tend to collect into groups of eight, this being the most stable combination possible. The rings, by reason of their magnetic fields, tend to attract one another if free to turn about, so that the magnetic lines flow in harmony, otherwise there would be repulsion. On colliding the rings vibrate, being elastic, and this vibration tends to hurl them apart again. The vibrating ring would have three, four or more non-vibrating nodes about the circle with vibrating internodes between. Contact of two rings, if made at nodes, would have no repulsive effect, but if at internodes, that is, on the vibrating segment, both are thrown apart by the energy of vibration. Thus there are two repulsive effects, caused by a magnetic and a vibratory action; and two actions that bring the rings in contact, simple motion in space, and magnetic attraction. Because of these properties of the rings, it can be seen that certain groupings are impossible or very unstable. It is assumed that the rings are uniform in dimensions. Two rings would not form a stable group, for while the magnetic attraction brings them together, vibrations of the segments would repel. Three rings would likewise be unstable as a group. Four rings, if their planes form a four-sided prism, would not remain thus, but would immediately move into an even more unstable position; if arranged with their planes forming a tetrahedron, would be broken apart by magnetic repulsion. In considering the rings as circles inscribed on the planes of the regular polyhedrons, it can be seen that the cubic system is unstable magnetically and the same is true of all the other regular polyhedrons with the exception of the octahedral system which conforms perfectly with the conditions of stability. Some other groupings are stable, but not being as simple and compact, under conditions of violent motion and great pressure would not survive the octahedral system.



VAN'T HOFF'S CONCEPTION OF THE NITROGEN ATOM.

The primary postulate—an elastic current-bearing ring—is capable of evolving, with the condition of motion, into a grouping of rings arranged on the planes of an octahedron. The properties of this octahedral system and the relations of one to another are very different from those of the simple ring and become more so as further additions of rings are made to it.

Additions to the eight-ring form might be made if one of its rings becomes pushed in slightly so that an extra ring in colliding lies over it with the three adjacent rings at their contacts separating the two. This nine-ring combination would still be arranged on the plan of the octahedron. The rings may be considered very thin, so that not until at least ten or more layers of rings had been added over the original eight, would the system become unstable, being unable to retain the added rings. The association in nature of utterly inert helium, corresponding to the original eight-ring form, with uranium of the highest known atomic weight is significant.

Each form in the system, whether composed of eight or eighty rings, would be vibrating principally in the outer layer of rings from the energy received in colliding, the inner rings of the heavier forms would be but slightly affected by vibrations, so that the energy received or given out through contact of other vibrating forms would be practically equal for light or heavy forms, provided but little of the total energy is used for free rotary or translatory motion, as in a solid. This condition parallels that of the elements expressed in the law of specific heat.

The addition of the ninth ring makes a great difference in the relations of the individuals. As long as any form of the system is free in space and colliding at intervals, it is revolving more or less rapidly; the sum of the attractive and repulsive magnetic fields in the vicinity of the eight-ring form is *nil*, as all of the fields are of equal magnetic value, alternately positive and negative. Near the nine-ring form there is a preponderance of either positive or negative lines, according to the location of the ninth ring, in a positive or negative position. There would be approximately an equal number of the two kinds of structures of nine rings, as there would be the same chance for either to be formed. The existence of two forms of the same element, one positive and the other negative, as an explanation of certain facts has been proposed lately by several, and although this view is rather a radical departure from that usually held, it is not without evidence.

If a free ring collides violently with the nine-ring form it would, in all probability, be hurled back; if more gently, it would be attracted by the preponderating polarity to those faces of the structure that are of the same sign. Thus the tenth, eleventh and twelfth rings added are of the same polarity, either positive or negative, as that of the ninth. The thirteenth, fourteenth, fifteenth and sixteenth additions must necessarily be opposite in polarity to the preceding. With the sixteenth addition the sum of all the magnetic lines near the rotating structure is *nil*, as in the eighth.

As rings are added and the structure has acquired several layers, the inner portions are at comparative rest. The energy of translation of the free ring has become vibratory energy in the segments, and this energy is dissipated into space, and on being covered by rings more recently added, becomes quiet. In space which at first was uniformly filled with free rings, condensation would begin to take place with increasing amount of radiation from the evolving particles. A limit to the increase of temperature produced by condensation would be reached when the supply of free rings in surrounding space was exhausted and cooling would then result. But the effect of gravitation upon the gaseous mass would be to maintain the temperature or even to increase as the particles draw closer to the center of gravitation. When this is at a maximum there would be dissociation (atomic disintegration) within the mass and free rings would be liberated to rise by reason of their lightness to the exterior. In this cooler region they would condense with one another and with any forms of the system they encounter. This would cause the condensing layers to radiate intensely, as the translatory energy becomes vibratory in the segments of the condensed structures. This suggests an important factor, hitherto unrecognized, of volcanic activity.

A comparison of the ring system in the various stages of its evolution with the elements of the periodic classification shows a remarkable degree of parallelism. Leaving hydrogen out of consideration for the present, helium is seen to have a certain correspondence with the primary eight-ring structure.

Inert, monatomic, gaseous helium stands in strong contrast with the other seven members of the series, while the eight-ring form occupies a similar unique position in its series, by all of its attractive forces being completely nullified by rotation.

As the sequence of valency of the members of the first and second or typical series is the especial characteristic wherein the regularity of the periodic classification is best shown, it is interesting to note the comparison with the ring system in respect to the fields of attractive force in their vicinity in the various members of the series. (The symbols *a* and *b* in the table represent opposite polarities, either positive or negative.)

Rings.	Rings Over Balanced Forms.	Stronger Magnetic Fields Resulting.		Fields Not Balanced (Active Affinities.)	Corresponding Elements.
		a	*b*		
8	0	0	0	0	Helium
9	1	1	0	1	Lithium
10	2	2	0	2	Beryllium
11	3	3	0	3	Boron
12	4	4	0	4	Carbon
13	5	4	1	3	Nitrogen
14	6	4	2	2	Oxygen
15	7	4	3	1	Chlorine
16	0 or 8	4	4	0	Neon
17	1	1	0	1	Sodium
18	2	2	0	2	Magnesium
19	3	3	0	3	Aluminium
20	4	4	0	4	Silicon
21	5	4	1	3	Phosphorus
22	6	4	2	2	Sulphur
23	7	4	3	1	Chlorine
24	0 or 8	4	4	0	Argon

The element carbon has been the subject of far deeper investigation than any other element and a great deal is known concerning it. Many of the properties of the carbon atom have been ascertained or deduced with a reasonable assurance of correctness. For example, the theory, of which the development is largely due to Van't Hoff, postulating that the four valencies of the carbon atom are directed toward the corners of a tetrahedron from its center, is generally accepted by scientists, and many facts are explained satisfactorily upon this assumption, such as the phenomena of rotation of the plane of polarized light in compounds where an asymmetrically placed carbon atom exists; also the stability of certain groupings of carbon atoms and various other phenomena.

The form of the ring system which corresponds to carbon is the one of twelve rings. It has the four added rings all of the same polarity, and examination of an octahedron shows the centers of these rings are in the direction of the apices of a tetrahedron as viewed from the center of the system.

Van't Hoff has enlarged his original conception of the relation of the valencies of the carbon atom in space to apply to the nitrogen atom. Pentavalent nitrogen, united to four different alkyl radicals and a halogen atom, is observed, in some cases, to rotate the plane of polarized light. According to his view four of the valencies are directed from the center toward the corners, not adjacent, of a cube (as was the case with carbon, this makes angles of 109 deg. 28 min.), the fifth toward one of the remaining corners. The figure and reference is taken from his work, "Atoms in Space." "Of these 1, 2, and 3, which have equivalent positions, correspond to the alkyls attached to the three chief valencies. When nitrogen is trivalent they lie in one plane with it, here they are somewhat displaced through the influence of the chlorine situated in 4, in 5 lies the fourth alkyl." The directions of these five valencies from the center of the cube are identical with those in the thirteen-ring form corresponding to nitrogen. If straight lines are drawn from the center of each ring to the centers of the adjacent rings, a cube is formed; four of the added rings of the same sign are at non-adjacent corners, the fifth is at one of the others being of opposite polarity.

The ring-structure is stable in its form, however, and the positions of the affinities fixed, whether pentavalent or trivalent, differing in this respect from the view quoted. Of the typical combination of NH_3 and HCl to form NH_4Cl the halogen hydride is a union of elements that are positive and negative to one another, the chlorine in NH_4Cl is consequently opposite in sign to at least one, and in all probability to the entire four hydrogen atoms. It seems that in nitrogen, as in the corresponding ring structure (thirteen rings), that pentavalence is the normal valency, but that one of these valencies is opposite in character to the other four, and in consequence this one can neutralize the effect of one of the others and this allows but three valencies to act ordinarily.

The combination $PCl_3 - Cl_2 = PCl_5$ agrees with the above type. The chlorine molecule Cl_2 is dissociated into its constituent atoms at a rather high temperature (comparable with that of the molecule HCl), and this with other facts, leads one to consider it a union of a positive and a negative atom.

In the elements of the first and second series there is a great difference of electrical behavior between the first four and the last four members starting with lithium and sodium. The first four are metallic or semi-metallic, conductors of electric current, and as such opaque. Li, Be, B, C, Na, Mg, Al, and Si contrast in many respects with N, O, F, Ne; P, S, Cl, and Ar. The latter are transparent, and are very poor conductors of electric current. Mr. Wm. Sutherland, in a recent article, associates the high dielectric capacity and ionizing property of such solvents as water and ammonia with the possession of latent pairs of valencies in oxygen and nitrogen.

The simplest orderly arrangement of a number of ring structures in a solid mass is on the isometric system of crystallization. If polarity can be made manifest in isometric crystals our ring system requires that all adjacent corners in cubes and adjacent faces in octahedral forms should be of opposite sign. The remarkable revelations of polarity in crystals by pyro-electric and piezo-electric phenomena show the analogy in this respect.

From the very simple postulate upon which this system has been developed so far, we are able to explain many facts, as the formation and structure of the hydrogen atom, the little irregularities of atomic weights in the elements considered, and especially the variation of the third series from the typical, and the peculiar elements, the iron group, occurring between the third and fourth series. Although in the fourth series there is a return to the typical condition so that Se, Br, and Ky, are quite similar to S, Cl, and Ar, the next series again presents the same peculiarities as the potassium-manganese series. There seems to be an alternation of properties in the succeeding series. Following caesium is a very remarkable succession of elements—the rare earths. The increase of atomic weight from caesium to the platinum group is great enough to include three ordinary series, yet the known elements included have the properties of but one series. No elements have been discovered having atomic weights between lanthanum and tantalum but what are extremely similar in character.

The first noticeable departure of the elements of the periodic classification from the typical series is in the elements following scandium, as Ti, Va, Cr, Mn, Fe, Co, Ni, Cu, and less apparently Zn, etc. The members of this series possess in certain combinations the normal valency which their place in the series would lead us to expect, showing that the tendency is to follow the same lines as the preceding series, but the normal conditions are overbalanced by some other factor which begins to manifest itself as above mentioned at about scandium. In the next series, on the other hand, the influence seems to cease after about gallium. A repetition of this same peculiarity is seen in the next series. The effect of the peculiar iron and palladium groups is to make two long series of eighteen. The middle members are characterized by great density, pronounced metallic condition, and stable and basic properties of the lower valencies.

In order to account for these facts we have in the already well advanced corpuscular theory of the X-rays and applied phenomena the factor which is needed to make a system such as we have already considered, conform with the remainder of the peculiarities of the periodic classification. As to how these particles might find lodgment in the structure, an examination of the rings, interspaces, and magnetic lines, shows a possible explanation. The corpuscles have been calculated to be about 1-1000 the mass of a hydrogen atom; their diameter may be therefore some size comparable to the thickness of the rings, which is also about the distance between rings which are superimposed. This space between rings would afford a place for these minute particles to become lodged. In the series following argon —using names of the elements corresponding—there are at least two spaces between the superimposed rings of each of the eight faces of the structure. The outer rings are strongly vibrating from collision with neighboring individuals, the next or middle rings in all probability are not entirely without vibrations, while the rings farthest within would be comparatively quiet. As the fourth shell of rings is added (K, Ca, Sc, etc.) a tranquil space would be formed and *not until this series would any form of the system possess a quiet space.* The magnetic field of force would be strong in these spaces, and a very large number of corpuscles would be attracted into it to become fixed there in a stable permanent position.

Corpuscles have been supposed to be revolving in some way about the atom, and it is not difficult to picture them revolving in more or less stable orbits about the sections of the rings. In the forms preceding potassium there are no places where the corpuscles could rest, and they can be retained only in this way, as vibration of ring segments would keep them from remaining in contact. The presence of these corpuscles would account to some extent for the variations from a regular increase in atomic weight in the series, for interference of orbits would introduce complexities and give to each form its peculiar capacity to retain corpuscles.

In the forms of the system past potassium the large number of corpuscles fixed in stationary position in the quiet spaces would have a profound influence on the properties of the system. There would be greater attraction between individuals and they would unite into groups or masses, so that lower valency would prevail. The constant valency MX_2 or MX_3, which repeats itself in long series of consecutive elements, as Ti, V, Cr, Mn, Fe, Co, Ni; and La, Ce, Pr, Nd, Sm, Gd, Erb, Tu, Yb, etc., regardless of the normal succession is to be found in the widening of the spaces, as following typical or normal elements as, Cl, Br, and I. This is due probably to the presence in these series of a compact cluster or group of constant form (6 or 8 atoms) where the most of the affinities are directed to members of the same group. The form corresponding to the inert member would not be able to rotate freely in space, as does helium, neon, and argon, owing to the immensely greater magnetic effects between atoms. Since iron, the first of the three of its group has the highest valency and the lowest atomic weight, it may be that the other two, nickel and cobalt, represent progressive steps in the direction which annuls the peculiar influence of the previously fixed corpuscles. In zinc and the elements which follow it is seen the weakening of the factor which gives the preceding series its peculiarities. In iron we may suppose that all the inner spaces are filled to their full capacity with corpuscles; by reason of the very intense magnetic field in the neighborhood of this first space, an additional set of corpuscles might be held in place in the second space, although normally a space so near the surface would be in too violent motion. The minute corpuscular magnets would be attracted so that they are turned with their like poles in opposite directions to those of the first space and mutually annul the influence on the field surrounding the ring structure. We may suppose that cobalt and nickel have the second space partly filled. As rings are added and the series Cu, Zn, etc., begins, this takes place to a greater degree and very rapidly the series reverts to the original normal conditions so far as the external field is concerned.

The series of the elements rubidium-iodine is quite similar to the potassium-bromine series, while the next, caesium-(bismuth), differs by being much longer. This extension takes place at a definite point in the series, beginning at lanthanum and extending to tantalum. The remainder of the series is like that of the two preceding ones. The next and last has but two positively known representatives, and these give some evidences of relative instability.

By assigning to our postulated ring a certain definite ratio between thickness and diameter these conditions can be more or less closely approximated. By assuming a ratio of too large a value a greater number of series would be possible and the "rare earth" extension would be in a different place. The cause of this extension is to be found in the widening of the spaces, as the rings are crowded together in the interior of the structure, allowing for a greater addition of corpuscles. There is a tension exerted by the outer layer of rings which are attracted to one another so as to make contact only at exact nodes of no vibration, but the inner rings may touch at greater distances from the nodes, and this happens as the rings of the interior are crowded together into one another. This also widens the space between rings where the corpuscles lie. The dimensions of the rings and corpuscles are such that the widening at this point takes place to an extent of allowing additional corpuscles to be added in the spaces already filled. The space which would be filling in accordance with its analogy with the potassium or the rubidium series is not participating in the disturbances farther in. These disturbances, due to the widening of the inner spaces, would have little or no effect on the field of force externally, as the corpuscular magnets are more free to yield to mutual directive influence and to annul the effect of one another at a little distance. These conditions allow not only for the same effects as were produced in the two preceding long series but cause a further addition of corpuscles in all the deeper spaces. Thus a large number of very similar forms are produced, differing mainly in the degree to which the filling process had been carried on.

In the platinum group the form of the system has eight complete shells of rings, making sixty-four in all. Judging from the atomic weight of helium (4), the rings must each weigh less than one-half that of the hydrogen atom. The weight of the platinum atom due to the rings would be less than 32. The number of corpuscles, if the calculated mass 1-1000 of the hydrogen atom is correct, would amount to over 150,000, but all would be in a condition of relative stability. The system here approaches the limit of stability, for in thorium and uranium the emission of corpuscles takes place readily and the analysis of gas evolved from certain ores indicates that *rings* had been set free to a slight extent, for helium as well as hydrogen is found to be present. (Hydrogen, which had no corresponding form in the system, as discussed, shows an atomic weight as if composed of two rings. The two might form a stable union, provided they are separated so as to make contact at regular intervals or nodes of non-vibration, by means of intervening corpuscles. This structure would produce at very high temperatures a simple "series spectrum" like that of hydrogen.) The small proportion of cleveite gases liberated on solution of the ore probably represents the product formed during untold ages of varying conditions. From the stellar evidence through the spectroscope (if we accept the interpretation of Lockyer), the temperature at which helium and hydrogen are formed from more complex atoms is so high that the greatest range of temperature at our command is insignificant. Stability evidently extends through an enormous range of temperature.

THE ROLE OF NITRATE AND PHOSPHATE FERTILIZERS IN THE RICHNESS OF WHEAT IN GLUTEN.*

THE study of the variation of the percentage of gluten in wheat presents special interest by reason of the necessity, from an alimentary viewpoint, of increasing the gluten in wheat, or at least of not increasing merely the total weight without reference to this percentage. The experiments, of which we have the honor of communicating the first results to the Academy, relate to the following points:

1. Influence of phosphate fertilizers on the percentage of gluten in wheat.
2. Influence of nitrate fertilizers on the percentage of gluten in wheat.
3. Study of the variation of gluten in hard varieties cultivated outside of the country of origin.

Influence of strong nitrated fertilizers on the total yield has been demonstrated. It is known also that the gluten increases when large proportions of nitrogen are employed. Our purpose was to determine in what measure this increase of gluten is produced, and to fix the relation existing between the increase of nitrogen in the fertilizer and in the wheat.

On the other hand, our experiments have been also directed to determining whether hard varieties of wheat, which are in general very rich in gluten, preserve this richness when they are cultivated outside of their native country, and under different conditions of climate and soil.

We have selected for investigation both soft and hard varieties. The first were represented by the "Golden Drop" and the Rieti; the second by the Medea and the Belotourka.

The first experiments were commenced in 1898 in the experimental field at the Lyons Agricultural Station at Pierre-Bénite on the Rhone.

The soil gave to analysis per kilogramme; nitrogen 2.10 grammes, phosphoric acid 0.10 gramme, potash 1.98 grammes. This soil may be considered as rich in nitrogen, which was rather unfavorable for our experiments.

The experimental plots numbered 12, each having 10 square millimeters of surface. Each of four varieties of wheat were sown in three parcels, A, B, C, which received increasing quantities of nitrate fertilizers; the other fertilizing constituents remaining the same, that is, with reference to the weight of the fertilizers per hectare:

	Nitrogen.	Phosphoric acid.	Potash.
A	35 kilos.	76 kilos.	50 kilos.
B	55 kilos.	76 kilos.	50 kilos.
C	75 kilos.	76 kilos.	58 kilos.

As might have been foreseen, the increasing percentages of nitrogen are manifested in the growing wheat by an increasing height of the stalks in the squares A, B, and C. The harvest could not be examined with reference to the yield in weight, on account of the small surface cultivated, and the irregularity in the grains sown.

The wheat of each plot was converted into flour with a mill allowing the operation of small quantities, and producing a bolted flour of about 70 per cent.

The gluten in these flours, dried at 100 deg. C., was analyzed, and the total nitrogen determined by the Kjodahl method. The nitrated matter was calculated according to the percentage in nitrogen. There is a substantial concordance between the gluten found and the gluten calculated:

	Nitrogen. Per cent. of grain.			Gluten. Per cent. calculated.			Gluten. Per cent. found.		
	A	B	C	A	B	C	A	B	C
Golden Drop.	2.23	2.39	2.47	13.93	14.93	15.43	14.70	15.30	15.69
Rieti	1.84	1.92	1.98	11.50	12.06	12.37	11.91	12.21	12.50
Belotourka	2.45	2.52	2.80	15.35	18.75	17.50	15.46	15.99	17.61
Medea	2.52	2.66	2.65	15.75	16.62	16.68	16.00	16.80	16.84

From these results the following conclusions may be drawn: The increase of the richness of the grain in gluten is augmented very slowly, for marked increases of the nitrate fertilizers, and it does not appear that, with reference to practical agriculture, there is occasion to increase the nitrate fertilizers beyond a certain limit, which is quickly reached. This limit cannot be deduced from our experiments, the soil employed presenting a richness in nitrogen sufficient to diminish the intensity of action of the additional nitrate fertilizers, and to conceal their effect in a certain measure.

In another series of experiments we have since sought to determine the influence of the phosphate fertilizers upon the variation of the gluten. On increasing the quantity of phosphoric acid, other conditions remaining the same, we notice a progressive diminution in the percentage of nitrogen in the grain.

The Golden Drop and Rieti wheats have been each cultivated in three parcels, A, B, C, receiving respectively 75 kil., 150 kil. and 225 kil. of phosphoric acid per hectare. The following percentages of nitrogen were obtained:

	Nitrogen.		
	A	B	C
Golden Drop	1.58 grm.	1.61 grm.	1.54 grm.
Rieti	2.07 grm.	1.90 grm.	1.82 grm.

It is known that phosphoric acid develops a production of starch in the grain. This augmentation of starch is correlative to a diminution of nitrogen, and to this cause must be attributed the diminution noticed in the richness of wheat in gluten. Millon ascertained that wheat harvested in the north (of France) contained much nitrated matter, from 10.23 to 13.02, while to-day the percentage of gluten is only from 8.96 to 10.62. It is not therefore, in the diminution of the richness of the soil in nitrogen, in cultivation on a large scale that it is necessary to seek for the cause of the loss noticed in the percentage of nitrogen in wheat, but in the prodigality with which phosphate fertilizers are employed, and of which the influence on the increase of the yield per hectare is known.—Communication of MM. Léon Vignon and F. Couturier to the Académie des Sciences. Translated from the French for the SCIENTIFIC AMERICAN SUPPLEMENT.

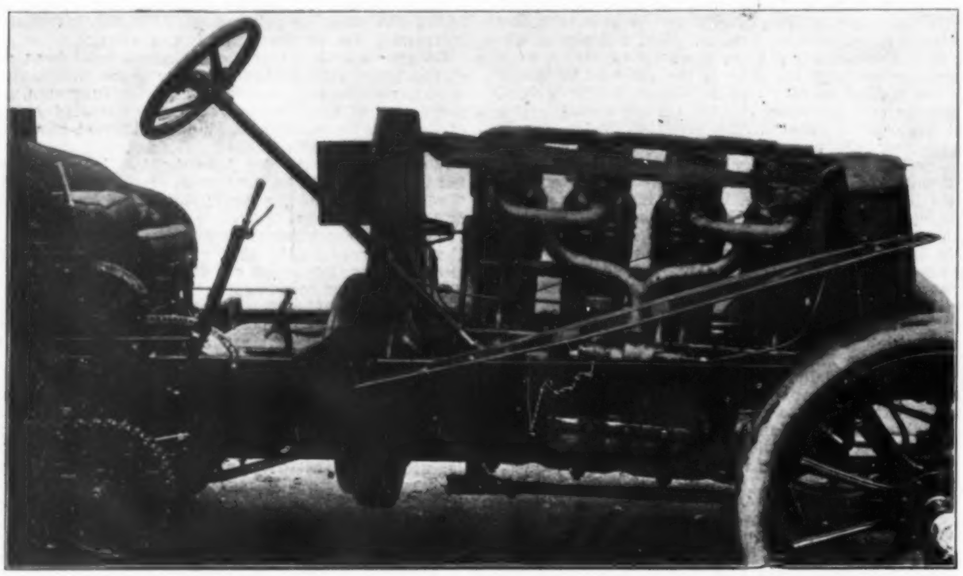
* Experiments of the Lyons Agricultural Station.

SOME DETAILS OF THE PARIS-MADRID RACING AUTOMOBILES.

Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT by our PARIS CORRESPONDENT.

I. THE PANHARD & LEVASSOR; CHARRON, GIRADOT & VOIGT; AND MERCEDES MACHINES.

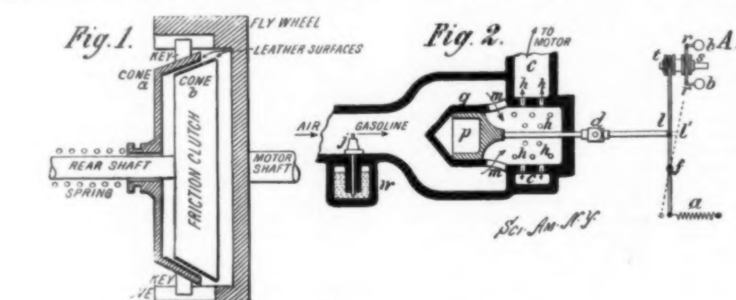
ALTHOUGH the Paris-Madrid race could only be run as far as Bordeaux, the event has nevertheless afforded a sufficient comparison between the different machines, and what is especially remarked is the high speed which most of the leading types are capable of reaching. Over parts of the road the winners must have made as high speeds as 70 or 80 miles an hour, and a great number of cars covered the distance from Versailles to Bordeaux, or 331 miles, in 5 to 6½ hours, making an average speed of 50 to 60 miles an hour. This remarkable performance shows that the design of the new cars has been greatly improved, and it will therefore be of interest to examine the construction of some of the leading types.



PANHARD & LEVASSOR 90 H. P. PARIS MADRID AND GORDON-BENNETT CUP RACER.

In the Panhard & Levassor machine, which is shown in the engravings, the chassis is built of wood, braced with steel plates and bars, and measures 8 feet, 4 inches long by 32 inches wide. The front and rear axles have been placed wide apart, being 7½ feet distant, while the wheels are spaced 50 inches apart. The front wheels are 35 inches in diameter and the rear driving wheels, 37 inches. The motor is placed in front of the chassis, carrying its flywheel, which is combined with the friction clutch, in the rear; then a short piece of shaft leads to the change-gear box, which is of the usual sliding gear type, but in this case contains only three speeds, this being found sufficient for the racing car. The countershaft drives the rear wheels by chains. The motor, which is built for 90 horse power, contains several new points. The four cylinders, of gun metal, are independent of each other, and are fastened to a long crank-case of aluminium. The upper part of the cylinder is surrounded by a water jacket of corrugated brass. The cylinders have a 6.4-inch bore and 7-inch stroke, which are the same as used on last year's type; but at present the motor is more powerful. It differs also from the preceding type in the disposition of the valves. The inlet valves are now operated by a set of cams, like the exhaust valves; and to make them lighter and easier to operate, a group of three small valves is substituted for a single large valve. The former are placed side by side in a triangular disposition. This arrangement has been found to give a decided advantage. The four exhaust pipes pass down the side of the motor and into a long cylindrical box 6 inches in diameter, which passes to the rear and serves as a muffler. An original idea has been adopted in mounting the motor. Instead of being placed horizontally, as usual, it is inclined downward toward the front. It was desired to make the flywheel heavier in the new type, and therefore of larger diameter, but as this would bring it too near the ground, the rear end of the motor was elevated so as to bring the lower rim of the wheel on a level with the front of the crank-case. This arrangement will be noticed in the view of the car.

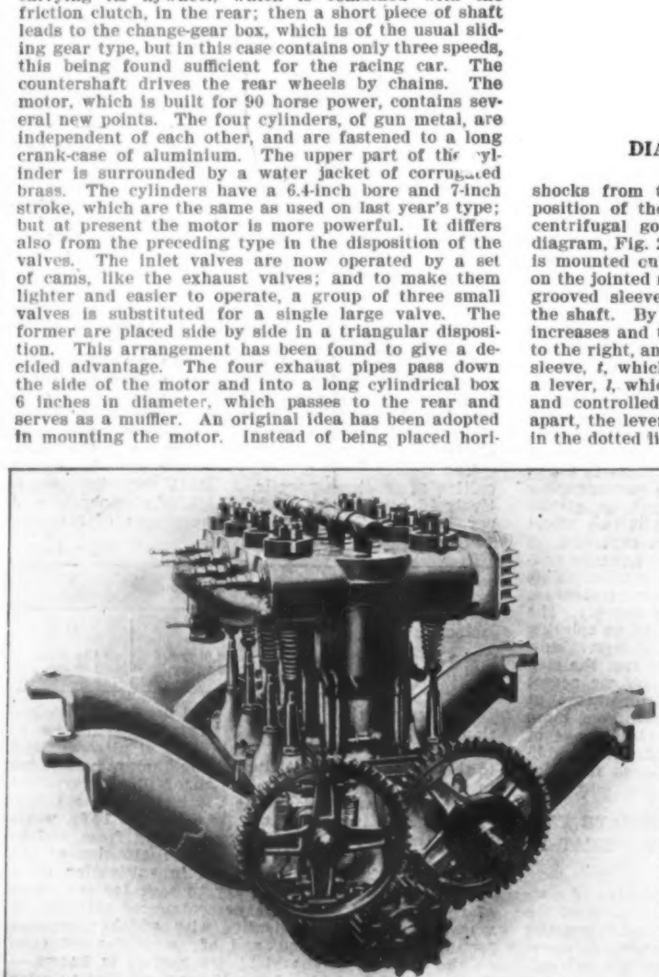
Another improvement is the disposition of the flywheel and friction clutch in order to free the motor shaft from the shocks caused by throwing the clutch in and out. As shown in the diagram, Fig. 1, the flywheel, which is mounted on the end of the motor shaft, is of hollow form, and the clutch is placed in the interior. The bearing surfaces are covered with leather. The outer cone of the clutch is provided with a key at each side, which slides in a groove on the inner side of the flywheel. The outer cone is thus driven by the flywheel, but is not rigidly connected with it, and the action of throwing the clutch in and out has no effect upon the motor shaft, while the latter is not subject to shocks from this cause. A new feature is the disposition of the carbureter, which is regulated by the centrifugal governor of the motor as shown in the diagram, Fig. 2. At the right is the governor, *A*, which is mounted on the motor. The balls, *bb*, are mounted on the jointed rods, *r r*, and the latter are connected to a grooved sleeve, *s*, which slides back and forth upon the shaft. By a suitable lever device, when the speed increases and the balls separate, the piece, *s*, is moved to the right, and *vice versa*. To it is connected a second sleeve, *t*, which also slides upon the shaft. It carries a lever, *l*, which is pivoted below at the fixed point, *f*, and controlled by the spring *a*. When the balls fly apart, the lever, *l*, takes the inclined position, *l'*, shown in the dotted line, coming back to the vertical when the balls resume their normal position. This to-and-fro movement causes a similar movement of the piston, *p*, which is connected with the lever, *l*, by a rod, *d*. The piston moves in a small cylinder, *q*, which has two openings, *m m*, at the side. At *W* is the gasoline reservoir in which plunges a wick, *j*. The evaporation of the gasoline from the wick gives the necessary supply of gas for the explosive mixture, and a rapid evaporation is caused by the inrushing air. When the suction of the motor occurs in the tube, *c*, a vacuum is formed in the chamber at the right of piston *p*, and the explosive mixture arrives through the openings, *m m*, filling this chamber, and thence passing into the tube, *c*, through the holes, *h h*. If the piston is drawn forward by the separation of the governor balls, the openings, *m m*, will be partly obstructed and a less amount of gas will arrive at the motor, thus cutting down the speed. A suitable device allows the governor to be thrown out of action when desired, and in this case the inlet holes, *m m*, are kept fully open. The gasoline reservoir is located in the box-shaped part which is noticed behind the driver's seat. It holds 35 gallons. The rear part of the box is occupied by the water tank, holding 10 gallons.



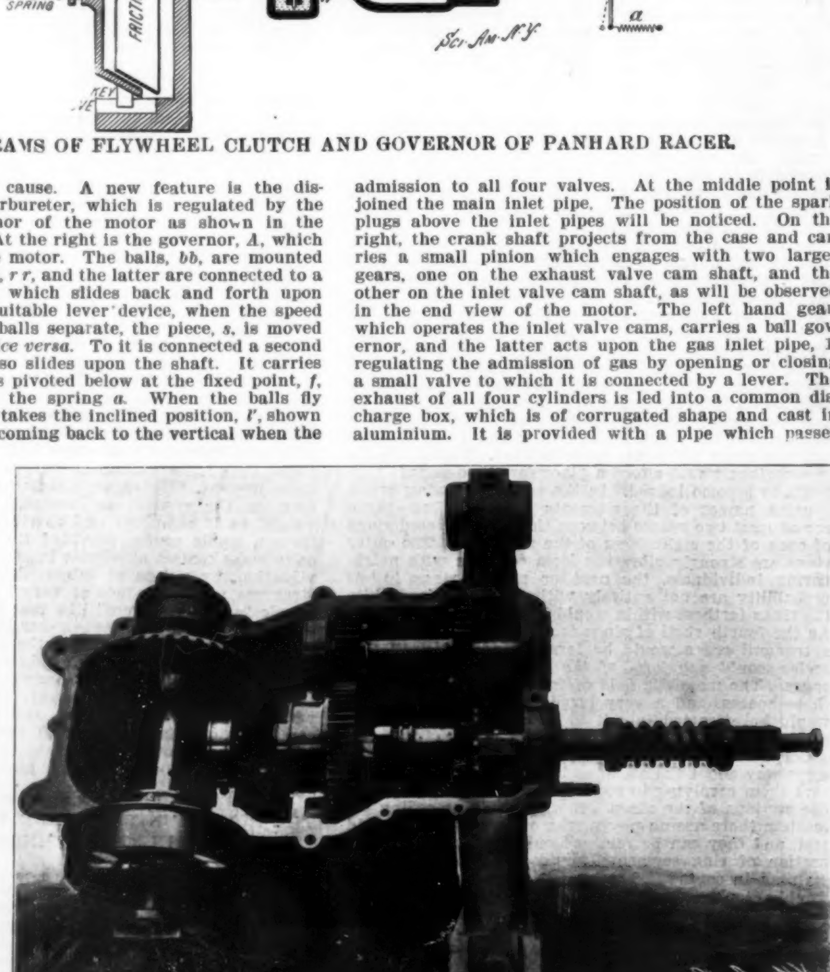
DIAGRAMS OF FLYWHEEL CLUTCH AND GOVERNOR OF PANHARD RACER.

The water circulation is carried out by a centrifugal pump worked by the motor. The radiator, placed in the forward end, is of the regular disk type and is built in a very compact form. As the use of the new carbureter allows the throttling to be made under specially good conditions, the motor can be run at slow speeds with very little heating; in this case the cooling is easily carried out, and a ventilating fan is not needed for the radiator. A small but useful point is the construction of the steering bar which connects the two front wheels. As this is the foremost point of the chassis, it is very likely to receive a shock upon striking an obstacle in the road. The bar, which is of steel tube, is protected along the front by a strip of ash, which takes up the shock; and the bar, instead of breaking off, simply bends and can be easily straightened out.

The Charron, Girardot & Voigt machine is one of the new types, but it has already gained a good place. The exterior of this car was shown in the preceding article. The new 40 horse power motor, which was designed for the racing cars, is represented in the different views. It has four cylinders of steel which are mounted independently. The upper part of the cylinder is surrounded by a light copper sheathing which forms the water jacket. The water pipe lies along the top of the motor. The inlet and exhaust valves are symmetrically disposed on either side of the motor. The front view shows the arrangement of the inlet valves. The cam shaft and the trips of the valve stems are mounted in pairs inside an aluminium cap, which is bolted to the crank-case. The four valve chambers are connected across by a casting which serves for the admission to all four valves. At the middle point is joined the main inlet pipe. The position of the spark plugs above the inlet pipes will be noticed. On the right, the crank shaft projects from the case and carries a small pinion which engages with two larger gears, one on the exhaust valve cam shaft, and the other on the inlet valve cam shaft, as will be observed in the end view of the motor. The left hand gear, which operates the inlet valve cams, carries a ball governor, and the latter acts upon the gas inlet pipe, 1, regulating the admission of gas by opening or closing a small valve to which it is connected by a lever. The exhaust of all four cylinders is led into a common discharge box, which is of corrugated shape and cast in aluminium. It is provided with a pipe which passes



FRONT VIEW OF C., G. & V. 40 H. P. MOTOR.



CHANGE-GEAR BOX AND DIFFERENTIAL COUNTERSHAFT OF C., G. & V. CAR.

below. It will be noticed that the crank-case is built in two parts, which are bolted together. The upper casting has two long arms, which are bolted to the chassis. The motor is cooled by a turbine pump driven from the cam shaft. The friction clutch, which is mounted on the change-gear shaft, has been considerably improved to secure an easy working.

One of the views shows the new speed-changing box which has been designed for the racing machines, and to this end has been simplified and made considerably lighter. The case is cast in aluminium in two halves. The lower half has two solid supporting arms. On the right is the motor shaft with the spring of the friction clutch. The box is divided into two halves by a partition which serves also as a support for the bearings. The front half contains the speed-changing gears, and this part has been reduced to one-half the usual length. One feature of the new transmission box is that all the shafts run in specially constructed ball-bearings, which give them an easy movement. On the high speed, the motor shaft is connected directly with the differential by a sliding clutch, and this dispenses with intermediate gearing. The differential has its shaft mounted in ball-bearings and carries a brake drum for a steel band brake. There is also a very efficient brake on the rear wheels.

The carbureter is of an improved type, and to assure constant carburetion at different temperatures, the mixing chamber is surrounded by a heating jacket in which the hot water coming from the motor is made to circulate.

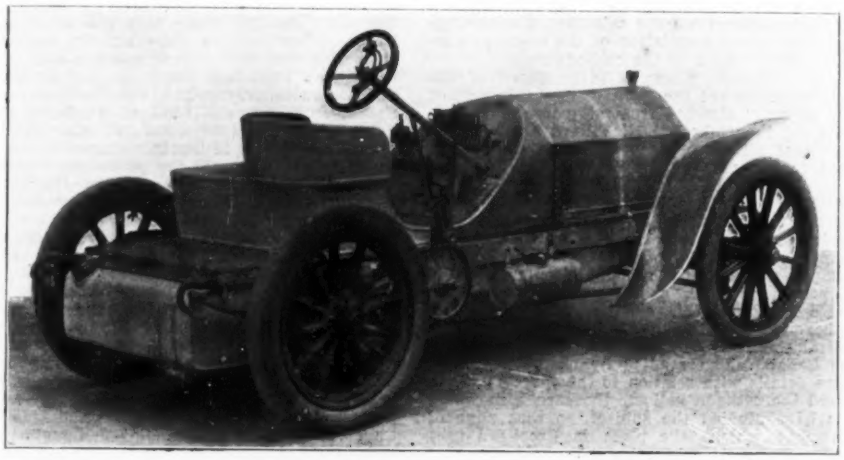
The German Mercedes car, which is built at the Daimler works at Cannstatt, is one of the favorites, and awakened great interest, as this was almost the first time that these machines, which have proved so successful, have been built as racing cars. The 60 and the 80 horse power cars, which are similar in exterior appearance, are shown in the engravings, together with some of the most interesting details which form part of the new design. The car is very long and runs near the ground, with the wheels, which are of equal diameter, spaced far apart. A four-cylinder motor is used in all cases. The motor cylinders are cast in pairs, as shown in the cut. At one side is noticed the piston, which is rather long. It will be remarked that the inlet valve is placed in the central position at the top of the cylinder. One of the valves detached is seen below. The valves have a relatively large diameter, so that they need be but slightly raised off their seat. The exhaust valves are on the rear side of the motor. Both inlet and exhaust valves are operated from the motor by a cam shaft. The Mercedes motor was the first to adopt the mechanically-operated inlet valve, which is now used so extensively. The ignition current is furnished by a magneto machine of the Bosch pattern, which is driven from the motor. The opening for the contact spark device is shown on the left hand cylinder, with the complete device in place on the right. The spark occurs inside the cylinder when the movable stem is rocked slightly by suitable tripping mechanism without, which is not shown in the photograph.

The Mercedes car uses an original form of friction clutch for coupling the motor to the change-gear mechanism. This is seen in one of the cuts, which represents the flywheel, *F*, with the friction-clutch in the interior of the hub, *H*. It will also be noticed that the flywheel is furnished with inclined arms, which form blades, thus causing it to serve as a ventilating fan at the same time. The friction clutch is seen somewhat withdrawn from the hub. The flywheel is next the motor body, while the front flange, *A*, connects the shaft to the change-gear box. The cylindrical part of the clutch is formed in reality of two semi-cylindrical halves, *C* and *D*, which are made to spread apart by an internal mechanism, and so form a clutch with the interior of the hub. To cause the segments to spread, the shaft carries a collar, *B*, which can slide back and forth upon it, and is shifted by the driver's lever. As the collar slides, it takes at the same time a rotary movement, as the key by which it is attached to the shaft is not straight, but inclined in helical form. The collar, *B*, carries a short segment of gearing which engages with a sector arm, *E*, pivoted inside the clutch. When this arm is displaced, it acts as a lever and causes the two halves of the clutch to separate and lock inside the hub. Thus when the collar, *B*, is shifted along the shaft, it takes a rotary movement and operates the arm, *E*, throwing in the clutch. The groove, *L*, on the front of the sliding collar, receives the fork which leads to the conductor's lever. This lever is worked by a pedal, and when the pedal is not pressed down, a strong spring, *S*, mounted on the shaft, keeps the clutch always thrown in. This device, which is quite simple in its action as well as solid, was adopted in order to dispense with the usual form of cone clutch. It also has the advantage of working without transmitting any shocks to the motor shaft.

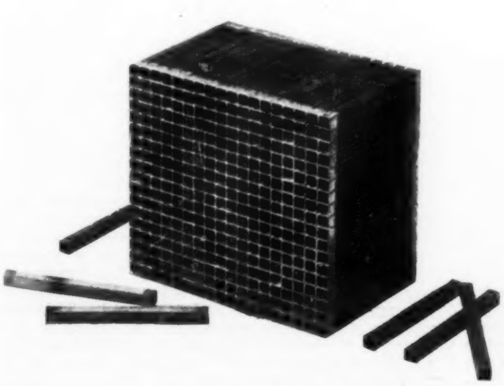
The upper part of the motor cylinder is surrounded by a water jacket which is cast in one piece with the cylinder. The water is made to circulate by a pump through a special form of "honeycomb" radiator which is mounted in front of the motor. The engraving below shows the construction of this radiator, which was first introduced by the Mercedes firm and has since proved a favorite. It is built up of a number of small tubes of square section. These tubes, as will be observed, are corrugated on the sides, so that when they are assembled together there will be a series of small canals through which the water can circulate. When the car is in motion, the air rushes through the tubes, and their sides afford a great cooling surface for the small amount of water they contain. The flywheel of the motor, which is built as an air fan, helps out this action, especially at the slower speeds.

All the working parts of the Mercedes car are oiled from a central automatic oiler which is fed from a reservoir. The latter works under pressure from the exhaust of the motor. The brakes are cooled automatically by water which is fed from a special tank. A second tank holds the lubricating oil, while a third contains the gasoline. In all the tanks the liquids are submitted to a pressure by a connection with the exhaust of the motor.

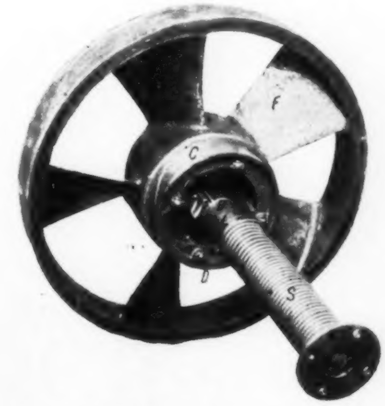
The Panhard and Mercedes racers represented France and Germany in the Gordon-Bennett Cup Race held in Ireland on July 2.



AN 80 H. P. PARIS MADRID AND GORDON-BENNETT CUP MERCEDES RACER.



NEW HONEYCOMB RADIATOR OF MERCEDES CAR.



THE FLYWHEEL CLUTCH OF THE MERCEDES CAR.

CYLINDERS AND PISTON OF MERCEDES CAR, SHOWING LARGE INLET VALVE IN CENTER OF CYLINDER HEAD.

SEVEN.

NUMEROUS are the queer beliefs concerning the number 7. From the very earliest ages the seven great planets were known and ruled this world, and the dwellers in it, and their number entered into every conceivable matter that concerned man. There are seven days in the week, "seven holes in the head, for the master stars are seven," seven ages both for man and the world in which he lives. There are seven material heavens. There are seven colors in the spectrum and seven notes in the diatonic octave, and the "leading" note of the scale is the seventh. Be it noted that the seventh son is not always gifted with beneficent powers. In Portugal he is believed to be subject to the powers of darkness, and to be compelled every Saturday evening to assume the likeness of an ass.—St. James's Gazette.

THE NEW RADIATIONS—CATHODE RAYS AND ROENTGEN RAYS.*

By A. DASTRE.

IT is generally agreed that one of the characteristic features of our age is the enormous development of the applications of science. This is a commonplace truth. We are completely surrounded on all sides by these applications; they are intimately mingled with all the conditions of everyday life; they take part in our housing, our clothing, our lighting, our transportation in many ways; they assist us in communicating with our friends, far and near; they produce our portraits, or they simply amuse us, so that they cannot be ignored. But this utilitarian aspect of modern science should not obscure its educational and philosophic value. Referring, for instance, to contemporary physics only, the march of ideas has not been less remarkable than the progress of discovery. Theory and practice have advanced side by side. Boldness of speculation has attained the same height as skill in experimentation. It may be said in this connection that the evolution of theories compares favorably with the marvelous development of facts, and the philosophy of science with science itself. This we have previously attempted to show to our readers in our essays on osmose, on cryoscopy, and on tonometry; here we wish to examine from the same point of view ideas that have accumulated in recent years concerning cathode rays, Röntgen rays, and on the radio-activity of matter.

I.

The term "cathode rays" was suggested in 1883 by the well-known physicist, Wiedemann, who had been engaged in studying them, but the object to which the name was applied was not entirely new. Cathode rays had several years before occasioned celebrated experiments in the hands of an English scientist, W. Crookes, long well known through other original investigations. The beautiful experiments of Crookes, disseminated by their author throughout Europe, had attracted the attention not merely of the majority of physicists, but of the public itself. Presented to the members of the British Association at their meeting at Sheffield in 1879, repeated in 1880 at one of the soirées of the French Association, held in the Observatory of Paris, these new and brilliant phenomena aroused immense enthusiasm. Crookes attributed them to a special condition of matter which he called "radiant matter." Cathode rays are simply radiant matter electrified. The English scientist laid great stress on this fourth state of matter; he believed, and others believed with him, that he had opened a new path to science.

This hope was vain, or at least deferred for a long time; it was necessary to wait fifteen years until the discovery of X-rays (connected with cathode rays, as will appear presently) attracted the attention of scientific men. However, investigators had not abandoned this new track; they had followed it with perseverance in the silence of their laboratories. Among these zealous workers must be named in the first rank the German physicist, Hittorf, to whom must be given the honor of having discovered cathode rays. He had pointed out their existence ten years before W. Crookes. In justice to him cathode rays might be called Hittorf rays, for the same reason and on the same ground that the X-rays are called Röntgen rays, and the radio-active rays Becquerel rays.

Besides Hittorf should be named Hertz, Wiedemann, and Ebert, Schmidt, Lenard, and J. J. Thomson, whose researches were gradually developed until 1895. At this period suddenly appeared the discovery by Röntgen, and investigations received a new impulse. Soon after appeared in different countries the publications of Birkeland, of Majorana, of W. Wien, and in France those of J. Perrin, of Villard, of Deslandres, and of H. Poincaré.

These numerous researches had a double object. It was proposed on one hand to complete the experimental study of the phenomena, and on the other hand to furnish an explanation of them. The task in both cases is very attractive, but the interest of the

* Translated from the Revue des Deux Mondes for the Smithsonian Report.

theoretical question is incomparably greater. In this new field of cathode phenomena was renewed the discussion which for more than a century had agitated the physicists concerning the interpretation of luminous phenomena. Cathode rays are not luminous rays, but their explanation was equally opposed to the theory of emission and to the theory of undulation, to ponderable matter and to ether. The discussion of the commencement of the century with reference to light was renewed in its last decade with reference to electricity. Sensational and theatrical effects succeeded each other. With Crookes in 1880 the emission theory triumphed; the cathode ray certainly appeared to be a material projection, a ballistic trajectory. With Lenard in 1894 (who had caused the cathode rays to penetrate a vacuum without diminishing the latter) the theory of an immaterial foundation, rays of ether, was uppermost. J. J. Thomson in 1897 returned to the emission of particles, but these projectiles were no longer molecules, atoms or ions—the smallest division of matter recognized—but the fragments of atoms, *atomic corpuscles*. Finally, M. Villard in 1899 determined the nature of these bodies, and showed that they were formed of hydrogen, in short corpuscles or fragments of atomic hydrogen. It was shown that the cathode rays exhibit the spectrum of hydrogen, and if every trace of this gas is successfully removed the cathode emission is suddenly suppressed.

II.

After this presentation of the theoretical interest of these new rays it will be well to give a short description of them. Their appearance is dependent upon conditions of the electric discharge in rarefied gases. Phenomena of this character are frequently seen, as for example, the illumination of Geissler tubes, or of the electric bulb. As these experiments are among the most brilliant and most attractive that can be performed with electricity they are shown on every occasion, as much for the beauty of the spectacle as for the instruction of the spectator.

Let us imagine, then, an electric bulb, an oval vessel of glass in which are placed two metallic poles, two bulbs or, in short, two electrodes of some shape or other, separated by smaller or greater intervals, and charged with electricity. Their electrification will be maintained, for example, by placing them in connection with the induction poles of a Ruhmkorff coil. An electrostatic machine can also be used, if furnished with a condenser whose collector is connected with one of the electrodes. A short tube provided with a stopcock allows the ovoid bulb to be exhausted of air. When the electric tension passes a certain limit a current is established. A flash of flame passes from the positive electrode (the anode) to the negative electrode (the cathode). Under these conditions, having a rarefied gas and suitable charge of electricity, this luminous trajectory, instead of being blinding white, sharp, rectilinear, or zig-zag as the ordinary spark is constituted, appears as a diffuse glow, varied in color according to the nature of the gas.

If the bulb or flask which contains the electrodes permits changing the place of the positive pole and approaching it to different points of the surface of the glass, the luminous trail is seen always to leave the wandering point of attachment in order to pass to the fixed negative pole. The passage will be more or less direct or rectilinear, it will approach more or less the axis of the bulb, and will vary in consequence with the shape of the same. And by displacing the positive pole, the current, this trajectory of discharge, can be directed at will. In ordinary cases this is what usually occurs, especially when the rarefaction is of a moderate degree, when the vacuum is maintained at a few hundredths, or at most a few thousandths of an atmosphere. One must not be contented with this degree of exhaustion if it is desired to study the cathode rays. It is necessary to go further, as did Lenard and Crookes, without, however, going too far. The English physicist, in particular, pushed the exhaustion to a prodigious degree. In the Crookes tubes, so called, the pressure is only one millionth of an atmosphere. The pressure of the remaining gas valued in millimeters of mercury does not reach more than 0.00076. The English scientist claimed that when exhausted to this point the residue no longer has the properties of ordinary gases; according to him it is a *hypergas* as different from the true gaseous state as the latter is from the liquid state, and forming a fourth condition of matter, following the liquid, the solid, and the gas proper; this he called radiant matter. Crookes, relying on what the kinetic theory teaches with reference to the constitution of gases, desired to determine the nature of this fourth state of matter. In reality, the gas, rarefied to the millionth of an atmosphere, has not acquired, by this fact alone, an entirely new character; but it has acquired it most certainly when electrification is added to the rarefaction, and it is then that it constitutes the emanation or the cathode ray.

We have said that the vacuum must not be pushed too far, if one goes beyond the millionth of an atmosphere—and the perfection of mechanism allows going much further than that—the gaseous residue cannot be electrified; electricity will not pass through; there is no longer a current. The electric force is incapable of penetrating absolute vacuum; this resistance of the vacuum to the passage of electricity is an article of faith among physicists, especially since the experiments of Walsh, of Morren, and of Schultz. The importance of this principle is very great from the theoretical point of view; it furnishes, in fact, a new test for matter. But in its application its practical value is very restricted. The experiments of Lenard, after those of Hertz in showing us the propagation of certain forms of electricity in vacuo, instruct as to the nature of these restrictions. We shall say, with J. Perrin, that it is very probable that recognizable electricity which can be experimentally detected cannot propagate itself without a material support, but this is not certain.

If now we return to Crookes's tube, in which the vacuum has been pushed to one millionth, we shall see that the current behaves itself rather differently from what it does in the tubes where the rarefaction is less. The path of the current has lost much of its brilliancy; it no longer appears as an uncertain glow, wavering, striated, of a hue intermediate between rose and violet. All the remainder of the interior of the bulb remains dark. The electricity passes again and follows the same path as before between the positive electrode and the cathode. The principal flow has been joined by a secondary one, from all points of the tube the positive currents are directed toward the cathode, and go to re-enforce the principal current. These positive charges which descend from all points of the periphery form the counterpart of the negative charges, which can be seen fixed on the cathode rays. Their existence, their development, their circulation, result in consequence from the existence, the development, and the inverse circulation of the negative electricity that carries with it the cathode rays.

Such is the cathode afflux; it is composed of the current directed toward the positive electrode and of secondary currents directed from all parts of the recipient toward the cathode. M. Villard has made it very plain that all these obscure or dim emanations are united in the axis of the bulb to the principal flow.

This cathode afflux has besides the character and the properties that physicists and chemists attribute to the electric current. It touches directly the cathode. If it happens that this negative electrode—which we may suppose to consist of a small, circular, metallic disk—is perforated with a hole, a portion of the cathode afflux crosses this opening and pursues its journey beyond, after being discharged in passing. This neutral electrical current, these discharged rays, form the Canalstrahlen studied by Goldstein.

All these details with relation to the currents which flow toward the cathode indicate the care with which physicists have studied the subject, so that none of the phenomena which take place in Crookes's tube may escape them. It might be said, however, that they are foreign to our principal subject, which is the cathode emission. The afflux which we have just seen reach the cathode is in fact perfectly distinct in every respect from the cathode radiation which follows it and which alone interests us. The latter is formed of a pencil of rays perpendicular to the surface of the cathode. It is in the present case a cylindrical pencil having for a base the circular disk: it traverses the tube in a perfectly straight line without being disturbed by the rays flowing toward the cathode in an opposite direction, of which we have just been speaking; it passes by them and through them unchecked.

This new pencil implanted normally on the cathode is not luminous. It is not directly visible; it forms a dark spot in the Crookes tube. It would entirely escape observation if it did not excite a peculiar fluorescence opposite to the cathode at the points where it meets the sides of the tube. The material of the glass becomes illuminated at these points and presents a luminous brilliant spot of a green color. Crookes had the idea to arrange in the interior of the tube, in the path of this pencil between the cathode and the wall, a variety of opaque bodies, as, for example, a cross of aluminium. He then saw outlined upon the clear fluorescent background the exact silhouette of the cross. In this way perfect geometric shadows of the objects introduced can be obtained in every case.

This experiment necessitates the conclusion that the cathode emission is rectilinear. The cathode, the screen, and the silhouette are all on a straight line. Things occur, in short, as if a single ray left each point of the cathode, exciting luminosity at the very spot where it encounters the walls. Without prejudging in any way the nature of the phenomenon, it is proper to use the expression cathode rays.

A close study of the shadows formed by divers screens, of the silhouettes outlined by these rays, leads to a new and instructive point; it shows that they are implanted at right angles to the surface of the electrode; they are perpendicular to it at every point. It must be added, however, following Goldstein, that it is not a strict rule; if accepted, it results that the shape of the pencil varies in a simple manner with that of the cathode. The latter is sometimes arranged as a slightly convex disk; thereupon the rays form the trunk of a cone which strikes the walls of the tube like a circular skullcap. If the cathode disk is a mirror with spherical concave surface, the perpendicular lines at the surface form a conic pencil and converge toward the center of the image of the sphere, where they form a focus. The effects peculiar to cathode rays are magnified by this concentration, in the same manner that the effects of luminous rays are increased in the focus of a lens. In this manner Crookes was able to show the heating action of his supposed radiant matter; that is to say, of cathode rays. He succeeded in fusing, at one of these foci, not only glass, but a wire of iridium-platinum, an operation which requires a temperature of more than 2,000 deg.

It is not only at the end of its path at the point where it strikes the walls of the glass tube that the cathode pencil can be rendered visible. Hittorf and Goldstein, in 1876, furnished the means of rendering it visible at all points of its path by discovering the phosphorogenic power of the new rays. The illumination which these dark rays excite in the glass of the bulb they also produce on other bodies placed in the interior. Rock crystal appears of a blue color, precious stones of divers colors, rubies project a beautiful red glow, diamonds take on an extraordinary brilliancy. The earthy sulphides which are naturally phosphorescent—that is to say, able to store up the luminous rays and yield them up afterward—are lighted up most vividly. Wurtzite (crystallized sulphide of zinc) becomes dazzling. By arranging a fragment of one of these substances in the path of the pencil, the latter becomes visible throughout. It becomes possible in this way to study the properties of cathode rays.

The results of this study should be briefly mentioned. In the first place the two laws already announced are verified—that the cathode ray is rectilinear and that it is quite sensitive perpendicular to the surface of the electrode. Again, the mechanical effects produced by these rays are of great interest, owing to the support which they seem to give to the theory of the emission of matter. They are shown by a beautiful experiment. Two rails formed of glass rods and placed in the path of the cathode rays support the axle of a paddle wheel. This little machine begins to move, revolves continuously as soon as electrical communication has been established, as if the flanges received blows—a bombardment, according to the expression used by Crookes—of material particles issuing from the negative electrode. On reversing the direction of the current the wheel revolves in the opposite direction. The ballistic explanation seems so reasonable that it naturally insinuates itself into the mind and gives rise to a belief in cathode projectiles. However, on reflection, the argument is by no means conclusive. Everyone has seen in the show windows of opticians the little instrument which is called a radiometer, which was itself an invention of Crookes. It forms a kind of windmill, exceedingly light, and inclosed in a bulb of glass that has been exhausted of air. It begins to move in the same way as the water wheel of the preceding experiment, but under the action of luminous rays—that is to say, of vibrations of the ether, without suggesting this time a bombardment of projectiles.

A second property of cathode rays, an unexpected and very remarkable one, is that they are attracted by a magnet. Making the pencil visible by means of a phosphorescent screen placed within the tube, it is seen to bend away on approaching a magnet; it can be attracted and repelled at will by varying the position of the magnetic agent. The amount of the deflection depends partly on the strength of the magnet and partly on the velocity of the cathode rays, a velocity which can be determined by varying the pressure of the gaseous residue that fills the bulb. On giving proper motion to the magnet it is easy to conceive that one might succeed in twisting the pencil into a spiral. This obedience to the directive force of the magnet goes so far as to allow it to form a circle upon itself. In this experiment the cathode ray behaves like an electric current of which the negative pole would be the cathode and which runs along a metallic wire. This magnetic deflection is easily explained by the emission theory; the rays would be formed by a row of electrified material particles following each other rapidly and carrying an electric charge. This transportation of electricity by the transportation of matter is called a current by convection. Rowland, Röntgen, and other physicists have shown that currents of this nature are similar to ordinary currents by conduction. On the other hand, deflections produced by a magnet are unknown in etherial, calorific, luminous, and actinic radiations.

In the third place the cathode ray is electrified. This we assumed a little way back in saying that it was similar to a row of electrified particles, that is to say, to a current. It is necessary, therefore, that the charge which it transports should be made manifest. Crookes believed that he had succeeded in doing this. Ebert and Wiedemann showed the fallacy of his demonstration, but it was a young French physicist, M. Jean Perrin, who, by a very neat experiment, made plain the essential character of cathode rays, which is that they must be charged with negative electricity.

The cathode phenomena, such as we have described them, fill the whole of the interior of the bulb; within it, it begins and ends. Up to 1894 it had been impossible to study these rays under the experimental conditions in which they occur. The rays remain shut up in their birthplace as in a prison. Lenard succeeded in liberating them, and his beautiful experiments of 1894, which drew these captive rays from their prison of glass, created great enthusiasm among physicists.

The cathode rays are stopped by glass; this is well known. Most other substances act the same way. However, Hertz in 1883 had announced that metallic plates would permit the passage of these rays provided they were sufficiently thin; their thickness should not be greater than a few thousandths of a millimeter (micron). Lenard suggested replacing the fluorescent portion of the glass tube on which the cathode pencil strikes by a piece of metal, and it was necessary that this plate should be stout enough not to yield to the pressure of the air. Herein lay the difficulty, which Lenard succeeded in overcoming. He arranged in his Crookes tube a small window, in which he inserted a plate of aluminium three-thousandths of a millimeter in thickness. This leaf proved to be capable of resisting atmospheric pressure and of sustaining the vacuum within. The cathode rays, more subtle than gaseous molecules, passed through, permitting them to be studied without.

They behaved without exactly as within the tube; they proved to be rectilinear, deflected by a magnet and capable of producing fluorescence; also equally capable of making an impression on a photographic plate. Most extraordinarily they had preserved their negative electrification in spite of the thickness of the metal which they had traversed. This fact was unexpected and unexampled. It indicates that the negative electrical charge is an essential and indelible character of the cathode ray, and that it cannot lose it without ceasing to exist.

These experiments taught at the same time that the cathode rays possess a very limited power of penetration, even through gases. Unless these gases are extremely rarefied the rays are quickly stopped and scattered by molecular obstacles. On the contrary, when the vacuum is pushed very far they remain unchanged; it has been possible to follow them the length of a meter and a half without noticing any diminution of power.

In conclusion, two other characteristics of the cathode rays must be noticed. The first consists in the power that they transmit to gases through which they pass, of conducting electricity. Gases in a dry state, as is well known, are nonconductors; an electrified body, for instance, a gold-leaf electroscope or a condenser, holds its charge. If it sometimes appears otherwise it is because the gas is not dry, and the diminution should then be attributed to the vapor of

water. But if a cathode ray just comes in contact with air which is really dry, near this apparatus, the latter is seen to discharge itself at once. The gas has acquired a certain degree of conductivity. This same property belongs, as we shall soon explain, to Röntgen rays and to Becquerel rays. This characteristic is common to all these radiations, and is probably the one which can be easiest investigated, and even measured. By means of an electroscope inclosed in a box full of dry air these divers radiations are studied. By this process Mme. and M. Curie discovered the new radio-active bodies, polonium and radium, and M. Debierne by the same means discovered actinium.

The last peculiarity is also common to these three kinds of radiation, as well as to every species of electric current. It consists in this, that both effect condensation of the vapor of water when the latter is near its point of saturation, producing a kind of mist. This mist, which forms instantly on the passage of the current, or of the rays, becomes a visible and palpable sign of their presence. It is a beautiful lecture experiment and one easily reproduced for public exhibition, and has often been repeated within the last two or three years. The invisible vapor escapes from a narrow tube connected with a flask full of boiling water; on approaching to it a metallic point strongly electrified and from which the fluid escapes in the form of an aigrette that can easily be distinguished in the dark. As soon as contact has been made the jet of steam assumes the aspect of a dense mist or of a thick smoke.

Allusion may be made to the possible applications of this phenomenon to meteorology without insisting upon them. There is another curious application which was made by J. J. Thomson in measuring the number of cathode projectiles which exist in a given space at a given moment. By combining this calculation with electro-metric investigations it has been possible by skillful comparison to determine the negative charge borne by each cathode projectile, and, finally, its mass. The latter is extremely small.

The cathode rays of a single pencil are not all identical. The velocity of propagation is not equal, and that is the reason why a magnet deflects them unequally, just as a prism bends unevenly the rays which form a beam of solar light. There is magnetic dispersion and a magnetic spectrum for the rays emanating from the cathode, exactly like the luminous dispersion and luminous spectrum formed with the sun's rays. This fact was determined about the same time by Birkeland and Jean Perrin.

By exceedingly clever experiments it has been possible to measure the velocity of propagation of the cathode rays, which is, according to the emission theory, the true velocity of the projectile thrown off by the electrode. This velocity is enormous and, moreover, varies greatly according to the circumstances of its production. It may be 200 kilometers a second, which is the lowest limit, and may reach 50,000 kilometers, which seems to be the highest limit, or one-sixth the velocity of light.

We can scarcely point out the principles by which this calculation has been made. It is founded upon the experimental measurement of the magnetic deflection exerted by a known magnet and by the electric deflection excited by an electric current having an intensity equally known. It is very clear that these deflections depend upon the velocity and mass of the cathode projectiles. In short, it is evident that the magnet or the current will deflect the cathode ray more if it travels with a feeble velocity and less if the velocity is great.

It is possible, moreover, to diminish this velocity in order to give greater accuracy to the methods. Lenard made use for this purpose not only of the rays produced in the Crookes tube but also of those the existence of which had been discovered by Gustave le Bon and which result from the action of light on metals.

The velocity of the cathode ray is prodigious and can produce mechanical effects surpassing the imagination, if you consider that the mass of the projectile is infinitely small and the projectile itself but the fragment of an atom. Jean Perrin has calculated one of the effects, the calorific effect which will be produced by the blows of an appreciable proportion of these projectiles. The quantity of heat which a kilogramme of this matter would generate, when suddenly arrested by an obstacle in its course, would be sufficient to raise instantly to the boiling point the water of a lake 1,000 hectares in extent and 5 meters in depth.

The measurement of the cathode velocity brings to bear a final argument in favor of the ballistic or materialistic theory. If the cathode were the result of certain vibrations of the ether, instead of resulting from the projection of matter, it would not be possible to comprehend that such a disturbance should be propagated with a variable velocity of 200 kilometers, since the same medium transmits the solar disturbance with a uniform velocity of 300,000 kilometers.

No matter from what side we study this question the advantage always remains with the theory of material emission. In this discussion which has been renewed in our time between the two systems of emission and of undulations, this time it is the first that carries off the palm.

The cathode ray may be considered, then, as formed of a row of projectiles negatively electrified. Why should they move in a straight line perpendicularly to the surface of the cathode? Because they are repulsed and driven violently by the electric charge of the cathode.

The electro-metric and electro-magnetic measurements, combined with those of which we have formerly spoken, and which allow the calculation of the number of cathode projectiles in a given space by means of the condensation of a mist have led to surprising results whose accuracy is amazing. By these means the cathode projectile has been found to have a constant mass, equal to the thousandth part of one atom of hydrogen.

The projectile, then, does not depend upon the cathode, as Crookes had already determined. It is composed of hydrogen, as proved by M. Villard without question. It has its origin necessarily in the breaking up of the atom of hydrogen. This, instead of being the final expression of simplicity and of lightness, as chemists believe, appears to be a quite complex edifice and rather heavy, since the current of the Crookes tube removes from the stones which represent it but the thousandth part of its mass. These stones are the fragments of atoms, or the atomic corpuscles of J. J. Thomson. The atom is no longer indivisible. Here we shall stop, not pushing the analysis further, although the state of science would permit it; but we should enter upon the subject of the constitution of matter, a subject which can only be incidentally referred to here.

III.

Cathode rays have no practical application. They are produced under extremely peculiar conditions, in a barometric vacuum, in the interior of a bulb from which it is almost impossible to liberate them. We should have no excuse for having entertained our readers so long had this study offered only the interest of pure curiosity and an opportunity of proclaiming the cleverness of our physicists. But it has another bearing. In narrating the history of these rays we have included that of rays of the same family —Röntgen rays, of which the applications are so numerous, and Becquerel rays, which are but a mixture of the two other kinds. In the second place, the cathode rays are the progenitors and the necessary generators of the others. The mechanism and the true nature of the latter are better known.

Moreover, cathode rays (and Röntgen rays as well as those of Becquerel, which accompany them or emanate from them) are not merely the simple results of design on the part of physicists; they constitute a natural phenomenon which cannot be neglected. Far from being of rare occurrence they are incessantly produced. Not a single ray from the sun falls upon a metallic surface, not a flame is ignited, not an electric spark flashes, not a current of electricity is produced, not a substance becomes incandescent without the appearance of a cathode ray either in a simple or transformed condition. G. Le Bon deserves the credit of having first perceived the universality of this order of phenomena. Although he, indeed, made use of the inappropriate term "black light," nevertheless he recognized the general character and the principal properties of this creation. Above all, he assigned to the phenomenon its true place, transferring it from the workroom of the physicist to the grand laboratory of nature. P. de Heen, the well-known professor of the University of Liège, adopted a similar conception. He considers that nearly all the centers of disturbance of the ether generate emanations similar to those which take place in a Crookes tube. We shall have occasion to return to this in connection with the radio-activity of matter.

IV.

The enthusiasm and admiration which the discovery by Röntgen aroused at the close of the year 1895 are well remembered. The learned physicist of Würzburg exhibited photographic silhouettes obtained through opaque bodies, sheets of pasteboard, leaves of paper, thick books, dictionaries, and wooden boards several inches in thickness. He furnished the means of receiving on a screen the fluorescent shadows of bodies concealed by wrappings, or inclosed in boxes, that is to say, made it possible to see indirectly through these obstacles.

Very soon useful applications added to the interest of mere curiosity which was manifest at the start. Radiography was applied to the detection of the sophistication of certain products, to determining the contents of a box without opening it, and to similar uses. But by far the most important of these applications was that made to medicine and surgery. Everyone has seen these radiographs publicly exhibited. They portray the malformations, the injuries of the skeleton, the alterations of bones, the presence in the tissues of foreign bodies, such as shot, needles, fragments of metal and the like, and in certain cases they disclose the existence of lesions in the viscera of divers kinds. When perfected, they will realize the dream and the aim of normal and pathologic anatomy, which is to show the body sound or diseased as if it was transparent throughout. It is useless to dwell further on these particulars; their history is developed right under our eyes and the daily press details its progress from day to day.

Röntgen rays derive their origin from cathode rays. Crookes's tube, the generator of cathode rays, was the means employed by the German physicist, and by all investigators who have followed him. But in this apparatus the only part useful for producing the effects which we have seen is the fluorescent spot situated opposite to the cathode from which it receives the emission.

From that point the new rays are projected in all directions and not merely in the original line. All substances which arrest the cathode rays become the starting point of Röntgen rays. It makes little difference whether a body is placed within the tube or whether it forms the wall of the tube, nor is it of any importance whether it becomes fluorescent or not under the cathode action; from the moment that it receives and arrests the first ray it generates the second. It has been found advantageous to arrange a slight modification of the apparatus in order to increase its power. An electrode is used having the form of a spherical mirror which concentrates the cathode rays at a single focus. Near it is arranged a platinum foil or some other infusible substance which intercepts the cathode emission and arresting it transforms it into Röntgen rays, which pass through the thinnest point of the tube and may be collected without. This apparatus is called a focusing tube.

The Röntgen ray is plainly to be distinguished from the cathode ray which has given it birth by several characters, of which the two most essential, from a theoretical point of view, are that it is not attracted by the magnet, and that it is not electrified. The cathode ray, on the contrary, carries an electric current and can be deflected by a magnet. On these two characteristics has been founded the theory of its materiality, as we have already said. They are wanting in the Röntgen ray, therefore we can not be sure that it results from the emission of matter. On the contrary, circumstances are in favor of its immaterial, ethereal, vibratory nature.

To these two distinctive, essential traits must be added the two following, which are no less important: The cathode ray has not the power of penetration. It is immediately absorbed or diffused; whereas the Röntgen ray is very penetrating and nondiffusible.

We have just seen that the Röntgen rays originate at the point where the cathode rays encounter solid substances. The violence of the blow of the cathode projectile against the material molecule disturbs it and increases its calorific energy; at the same time it makes the surrounding ether oscillate and produces the fluorescence of Crookes's tube. The operation which produces the X-ray yields then, at the same time and accessorily, luminous rays (visible fluorescence), and at other times chemical rays, ultraviolet rays (invisible fluorescence), and probably still other unknown radiations.

Setting aside these accessory radiations—that moreover may be absent—in order to consider the principal one, we have said that the latter is disclosed by its chemical action on the salts of silver (photographic impression) and by its power of exciting the luminosity of phosphorescent screens. If an opaque body is placed in a straight line between the source of the ray in the screen its shadow appears thereon with an astonishing distinctness. The formation of these geometric shadows proves a perfectly rectilinear propagation and justifies the name of "ray" here employed.

At the outset the most surprising characteristic of these rays is their power of penetration. They pass as easily through a volume of a thousand pages as a ray of light passes through a window pane. Both cases exhibit the same prowess of nature; and if the latter fact no longer astonishes us, it is because, as Montaigne says, "familiarity with things removes from them their strangeness." Our surprise arises in observing the newcomer accomplish that which was impossible for our old friend, light. We were formerly no less surprised to learn that the ultraviolet rays of the solar spectrum passed through a piece of silver foil, which, we may say, parenthetically, made possible for the first time photography of the invisible. That which is permitted to one ray is prohibited to another. Röntgen's ray, which traverses an oak plank 2 inches in thickness and a plate of aluminium more than a centimeter thick, is stopped by several meters of atmospheric air, the passage of which is but a trifle for the ray of light.

There is another difference between the Röntgen ray and the luminous ray—their conduct in the interior of bodies. Both these rays are absorbed while on their journey; their nature is changed; they are annihilated; their energy is transformed into some other force—heat for instance. This end is common to them. But light has another property which is peculiar to it. In certain bodies having a granular structure, such as roughened glass and the powder of rock crystal, the light is diffused; the path of the rays is broken by reflections and by numerous refractions. Each particle, then, behaves as a source of light, emitting rays in all directions, and the body is illuminated. It would be useless to increase the intensity of the beam of light with the expectation of seeing it transmitted; the illumination would only be increased.

The Röntgen rays behave very differently. They are only lost through absorption. By increasing the intensity of the rays they will be seen to gain more and more in the power of penetration. They are not diffused. They pursue their path rigidly inflexible, undoubtedly weakened, but never deflected by any obstacle. A ray of light should not be taken as the type and symbol of ideal rectitude, but rather the ray of Röntgen.

There are several varieties of Röntgen rays, as there are of cathode rays. They form an entire scale, and may be distinguished from each other by their degree of penetration. Some are ultrapenetrating. Others are extinguished at a distance of a few millimeters from their origin. This depends upon the generating apparatus, on the current employed, and on other circumstances controlling their production.

When a Röntgen ray happens to strike a solid body, particularly a metal, it gives rise to rays of the same nature, but having less penetrating power. They are also much more active from electric and photograph points of view. These secondary rays have been studied by M. Sagnac. In the same conditions the secondary rays originate tertiary, and so on, in such a way that there exists at the surface of metals struck by Röntgen rays a whole system of radiations, which form a complicated envelope, conducting electricity and photogenically active.

It is easy to see that the fact that Röntgen rays are not diffused entails other differences between them and light, and these are important. The rays are not diffused, because they do not submit to reflection or to refraction. Their reflection has been thought possible at times, because they were mingled with other elements—for example, ultraviolet rays. M. Gouy has shown with wonderful accuracy that in reality they do not suffer the slightest refraction. They do not exhibit the phenomena of diffraction or of polarization.

Reflection, refraction, diffraction, polarization, and interference are universal characters of ethereal vibrations. They belong to all the rays of the spectrum, from the slowest to the most rapid. They are common to Hertzian vibrations, to the infra-red or calorific, to the visible vibrations, and finally to the ultraviolet or chemical vibrations. As to interference, the opinion of the scientific world is divided on the point whether Röntgen rays allow this or not. It appears, however, that the phenomena observed by M. Jaumann, by means of two parallel electrodes connected with the negative pole of the coil by wires of equal length, should be regarded as illustrative of interference.

Is it possible after this to compare Röntgen rays with luminous rays, or even to attribute to them any form of ethereal undulations? This is the general

tendency. Wiedemann and Lenard regard them as forming a new round in the spectrum ladder beyond the ultraviolet. Röntgen and Jaumann consider them as the products of longitudinal vibrations of ether.

Röntgen rays discharge electrified bodies placed in their neighborhood. The rudiments of this electrical property are exhibited in the spectrum; ultraviolet rays destroy the negative charges of bodies with which they are brought into contact. This shows a greater or less analogy between the two kinds of radiations. It is only, however, under certain conditions that the Röntgen rays may be referred to small undulations, having the character of undulations of light, and thus continuing the spectrum beyond the violet. It would be necessary to conceive of these undulations as exceedingly short, or what is the same thing, that the vibrations are very rapid, which is a means of rendering the interference less appreciable, and still more so the diffraction. Besides, the velocity of the propagation cannot be different in the air and in the other bodies. *A priori*, this supposition is not improbable—it explains the absence of refraction and renders possible that of reflection. On the other hand, since there is no other way of realizing polarization except through recourse to simple or double reflection, which are here insufficient, it is not surprising that the Röntgen rays are deprived of this property. Thus deprived of all its burdens and functions it yet possesses transverse vibrations, which place it in the family of spectra; but in these surroundings, after all the diminutions, restrictions, and limitations which it has undergone, it appears rather like a mangy sheep. We have said that some physicists are contented with this state of affairs.

The same difficulties arise if the longitudinal vibrations of the ether are introduced into the theory, and there is added, moreover, the uncertainty of the existence of these vibrations. There is nothing to prove, in truth, that they do not exist; on the contrary, it is evident that they are formed as soon as luminous rays change their direction, are reflected or refracted. They could not be neglected except by regarding the ether as strictly incompressible. Some physicists affirm that it is, and, in short, if one relies upon experimental grounds it is sufficient to say that the longitudinal component can be neglected, owing to its insignificance. This is true if one ignores all the phenomena which can accompany the manifestation of light.

In fact, by disregarding the longitudinal vibration, satisfactory agreement, as is known, is found to exist between theory and experiment. It is possible that the Röntgen ray may be due to this longitudinal vibration, but this remains to be proved. Jaumann has endeavored to demonstrate this, but was refuted by M. H. Poincaré.

Besides these explanations there is a third, which consists in saying, with M. A. Schuster, that the vibration of the ether which yields the Röntgen ray is not strictly periodic; periodicity being a condition of interference, a troublesome objection is thus removed. On the other hand, explanations founded on the theory of the emission of matter are also problematical. M. Jean Perrin claims that the Röntgen ray is due to the vibration of atomic corpuscles, and is produced by their violent encounter with material molecules. This hypothesis has also the advantage of taking into consideration the conditions of its production. In conclusion, very little is positively known of the nature of this physical agent, which, to quote M. Bouty, has remained exceedingly mysterious in spite of the united efforts of the scientific world.

HERTZIAN WAVE TELEGRAPHY.

FIRST PAPER.

PROF. J. A. FLEMING, D.Sc., F.R.S., recently gave a series of four Cantor Lectures at the Society of Arts on "Hertzian Wave Telegraphy in Theory and Practice." Dr. Fleming is retained by the Marconi Company as their scientific adviser, and this of itself lends a great interest to all he says on the subject of wireless telegraphy.

The following abstract has been published in Engineering:

Dr. Fleming said that it was undoubtedly true that wireless telegraphy was a very popular subject; it was to be found discussed in papers and magazine articles innumerable. The daily press often furnished absurd statements on the subject; they seized upon any sensational report and gave it publicity, whether it was right or wrong. The magazines, as a rule, were more correct; but even they were lacking in many particulars and were sometimes even erroneous. It was evident to him on consideration that there was room for more general treatment, and he was about to aim at giving a summary of the present state of knowledge on the subject, directing himself rather to an elucidation of the principles on which it rested, than to an account of the performances which had actually been carried out. He should confine himself to that form of aerial telegraphy known as Hertzian wave telegraphy, because without doubt that form, owing to Mr. Marconi's transatlantic work, had the greater interest for us at present. There were other methods of aerial telegraphy, as everyone knew, but he did not propose to deal with them. Neither did he intend to give a history of the subject or of the inventions which had been made in connection with it. He aimed rather at an exposition of the principles, and at making clear the inner meaning of the phenomena upon which the action of aerial telegraphy depended.

The problem of aerial telegraphy lay in the production of electric waves in the ether, and their reception at a distance, and it was this which he hoped to make intelligible to his audience. The first lecture would be devoted principally to an account of the production of an electric wave, and the theory of the "aerial" or radiator; the other parts of the subject will be dealt with in later lectures. It would assist his audience if he began by putting an analogy before them, showing the likeness there was between the transmitting wire and the siren as a means for generating sound signals.

On Fig. 1, annexed, there were illustrated in diagrammatic form a siren and an electric oscillator. The siren comprised a pump *I*, a receiver of compressed air *C*, a valve *K*, a rotating disk *S*, with holes in it, moving under a fixed disk of the same description, and an air pipe *A*. As everyone knew, air was compressed and stored in the reservoir, and when the valve was opened the disk *S* was caused to revolve, alternately emitting and cutting off air currents, which were delivered into the vertical pipe *A*, there producing a note. Similarly the electric oscillator comprised a generator *B*, a coil *I*, which served as the equivalent of the pump, a spark-gap *S*, corresponding to the disk *S*, a condenser *C*, and a vertical wire *A*. The spark-gap alternately allowed the energy of the coil to pass and be stopped, sending impulses into the wire *A*, which set up in it electric vibrations, corresponding to the vibrations of the tube *A* of the siren.

To-night he was going to speak of the "aerial," or radiator; that was, the tall wire which corresponded to the tube of the siren, and sent electric waves off into the ether in the same way that the siren sent air waves into the atmosphere. This led him at once to the root of the subject. What was the relation of the ether to electricity and to matter? Ten years ago it would not have been possible to give an answer to the question in an intelligible form, and even five years ago the answer would have been doubtful; now, however, thanks to the researches of J. J. Thomson and Larmor in the electronic theory, a very great deal was known on the subject. Indeed, the matter had become so popular that articles had even appeared on electrons in the Daily Mail. He would commence by giving a very slight sketch of the electronic theory. Electrons were the constituents of which the atoms were built up. The word "atom," as meaning that which could not be divided, was now a misnomer; atoms were built of electrons, as a house was built of bricks. Of course, the question followed: What was an electron? The insatiable curiosity of the human mind was always asking questions of that kind, and it led them into a region of speculation and hypothesis. Larmor said that an electron was a center of convergent strain in the ether. To render this more intelligible, he had prepared a model, consisting of a ring like the tire of a wheel, with a number of spokes radiating from the center, each spoke being a ribbon of paper twisted up about its own axis, something like a corkscrew. Now if, instead of a ring being used, he had taken a sphere, and filled that with these twisted spokes from the center to the periphery, that would have been a model of a center of convergent strain; at any rate, it would have given his audience some conception of such an idea. These lines of strain could move about in the ether; they were not things that had a fixed place, just as a kink was not a thing. If he took a ring of paper with a kink in it,

Fig. 1.

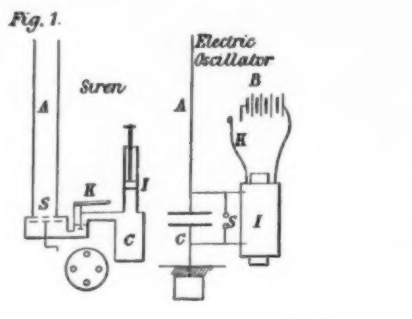
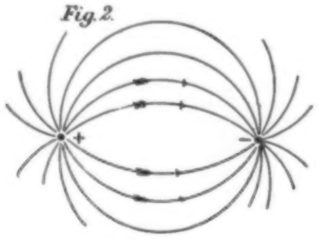
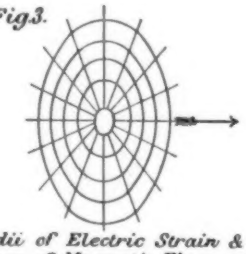


Fig. 2.



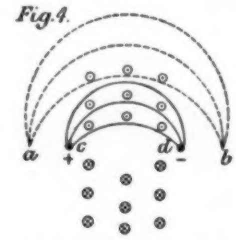
Lines of Electric Strain between an Electron – & Co-Electron + at rest.

Fig. 3.



Radii of Electric Strain & Rings of Magnetic Flux round a Moving Electron.

Fig. 4.

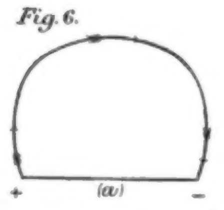


Shrinking Lines of Electric Strain producing Rings of Magnetic Flux as Electrons oscillate to & fro slowly.

Fig. 5.

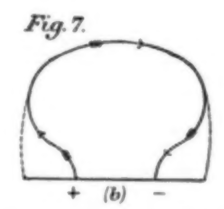
Rings of Magnetic Flux round Linear Oscillator.

Fig. 6.



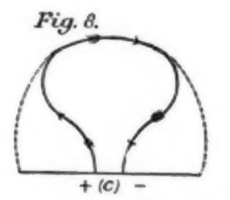
Line of Electric Strain due to a pair of Electrons + and –

Fig. 7.



Line of Electric Strain due to pair of Oscillating Electrons.

Fig. 8.



Line of Electric Strain due to pair of Oscillating Electrons.

Fig. 12.

Simple Marconi Aerial Radiator.

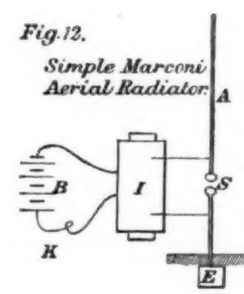
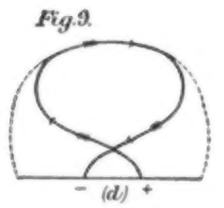
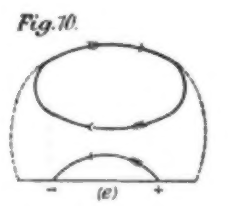


Fig. 9.



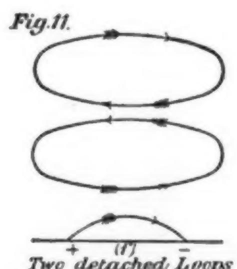
Line of crossed Electric Strain due to Vibrating Electrons.

Fig. 10.



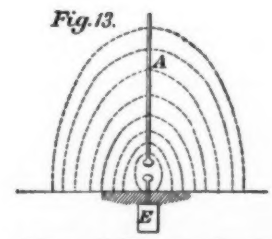
Detached Loop of Electric Strain due to Vibrating Electrons.

Fig. 11.



Two detached Loops of Electric Strain.

Fig. 13.



Lines of Electric Strain round Marconi Aerial before discharge

He could move the kink anywhere round the ring or with the ring. Atoms then, according to this theory, were arrangements of the ether, and so were we. The hypothesis of a strain involved doubleness in some form. You could not strain anything by a single action; there must always be reaction as well. You must hold a thing by both ends if you wished to twist it. The electrons therefore must be considered to be in pairs, there always being a positive and a negative electron in the pair. It could be shown that it was possible to detach one or more electrons from an atom, and what was left was called the "ion"—that is, a wanderer—but he preferred to call it a "co-electron." When an electron left an atom, it was connected to it by lines of electric strain, as shown diagrammatically in Fig. 2; this connection always persisted, whether the two were separated by an inch or a mile, there was always a line of strain forming a connection between them.

It could be shown mathematically, in a way that would take far too long for him to attempt at that time, that the motion of an electron created other kinds of strain at right angles to the first strains, these latter being magnetic. Fig. 3 shows by its radii the electric strain caused by the movement of an electron, while the circles represent the rings of magnetic flux at right angles to the first strains. If the electron moved at the speed of light, the strains were confined to the equatorial plane. When the positive and negative electrons moved together, the lines of electric strain were somewhat as shown in Fig. 4. Fig. 5 showed three rings of magnetic flux round the linear oscillator. An electric current was a procession of electrons; a continuous procession in the case of direct currents, and a to-and-fro movement in the case of alternating currents. It was necessary that the audience should not think of atoms as being hard continuous bodies, like marbles. Electrons must be imagined as being very small, as compared with the atom, and might be compared to a few gnats moving about in the dome of St. Paul's, the gnats being the electrons, and the dome the atom. It had been calculated that an atom of mercury would comprise 100,000 electrons. The electrons were not necessarily permanently connected with one atom; there was an exchange of electrons between atoms; they went from one to the other in the same way as a man might visit a number of offices in the city. The identity of the atoms was identity of form, and not identity of matter, just as in human beings the matter changed from day to day by waste and repair, but still the individual remained the same. The electron passed to and fro from atom to atom. Some, in solid substances, were fixed in coalescence, while others moved about, it might be, in the form of electric currents. Now, when the atoms moved very rapidly they set up a state of strain in the ether, because it had a quality which was comparable to inertia; it could not be instantly put into rapid motion, and it could not be instantly brought to rest. Indeed, it was probable that the inertia of matter with which we were acquainted was an electrical phenomenon; at any rate, ether displayed the quality of inertia, and had a time element the same as other bodies. Figs. 6 to 11 on the opposite page showed this diagrammatically.

Fig. 14.

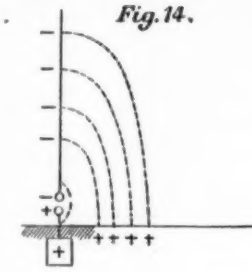


Fig. 15.

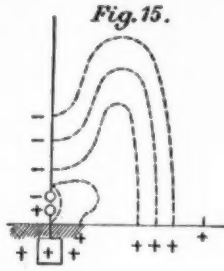


Fig. 16.

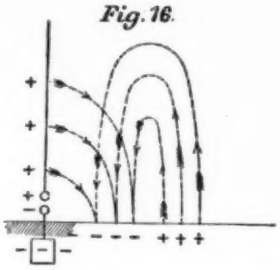


Fig. 20. Closed Organ Pipe.

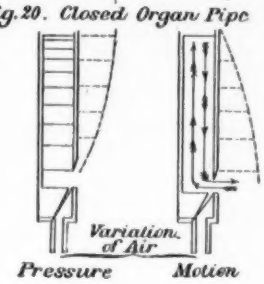


Fig. 17.

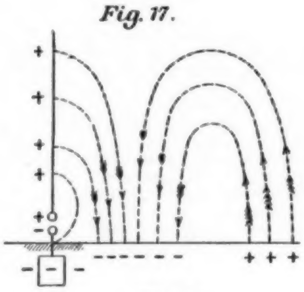


Fig. 18

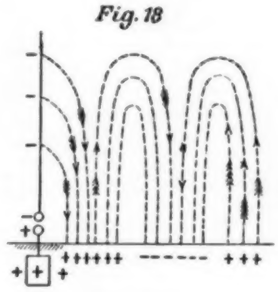


Fig. 19.

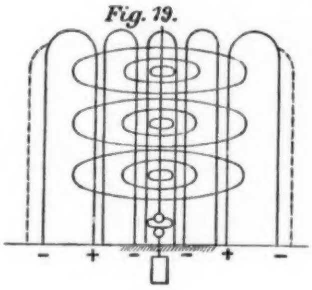


Fig. 21.

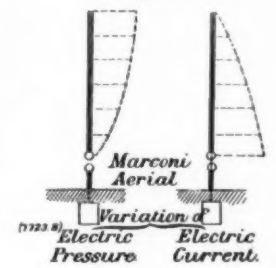
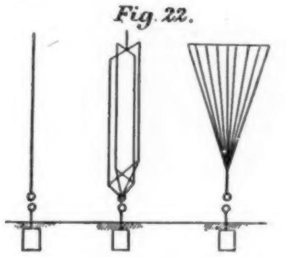
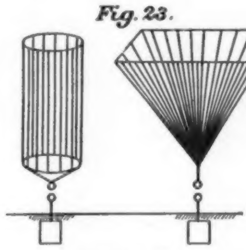


Fig. 22.



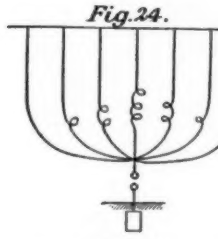
Marconi Aerials.
Simple. Quadruple Multiple.

Fig. 23.



Marconi Aerials.

Fig. 24.



Equi-Periodic Aerials.
All wires same length widespaced.

Fig. 25. Marconi-Braun Radiator.

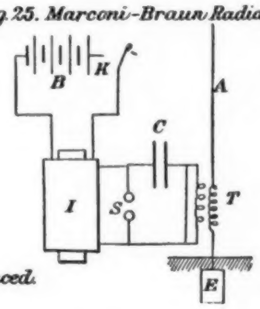


Fig. 26.

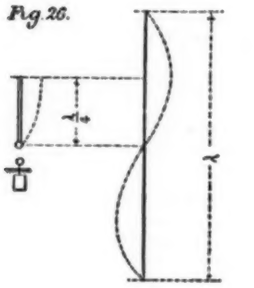


Fig. 27.
Harmonics of Open Organ Pipe.

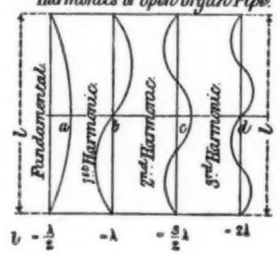


Fig. 28.
Harmonics of Closed Organ Pipe.

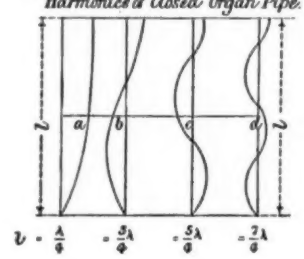


Fig. 29
Braun Radiator

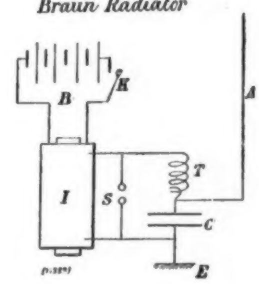


Fig. 30.

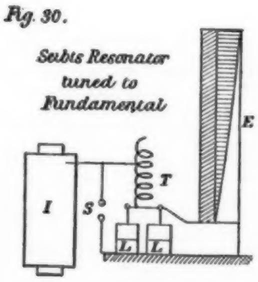


Fig. 31

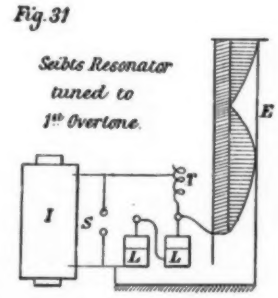


Fig. 32.

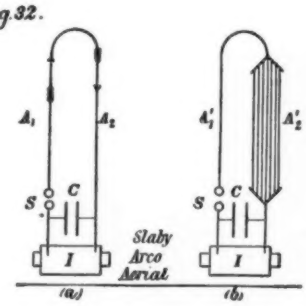


Fig. 33.

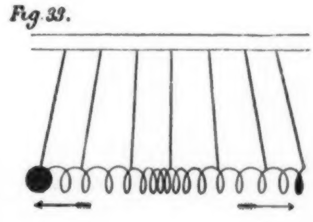


Fig 34

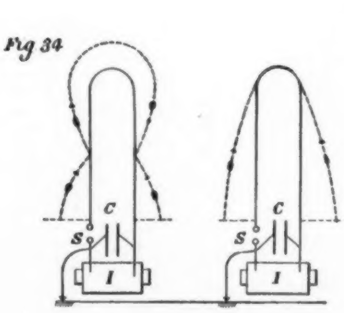
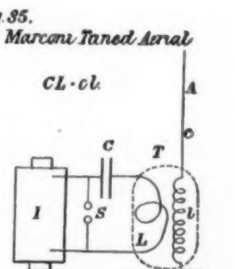


Fig. 35.
Marconi Tuned Aerial



When the pair of electrons + and — suddenly moved toward one another, they distorted the loop of strain by which they were connected, bringing its ends into a kind of horseshoe form: first as shown in Fig. 7, then as in Fig. 8, finally causing the loop to cross, as in Fig. 9, and then throwing off a loop of strain, as in Fig. 10. When the electrons were rapidly vibrating to and fro, they continued to throw off successive loops, as shown in Fig. 11, and these were detached into space. It was possible that in this way light was developed. This production of loops from electrons was the work which was carried on by the aerial, or radiator, in wireless telegraphy. His hearers should guard themselves against considering that the electric waves were necessarily like the waves they have seen at the seaside; waves in an infinite medium were not necessarily to and from or up and down. The definition of a wave was that it was a variation in space and in time of any matter that was variable; consequently there were many kinds of waves.

Fig. 12 showed a simple Marconi aerial radiator. *A* was the vertical wire separated from the earth wire by a spark-gap *S*, the two wires being connected to the two terminals of a coil *I*, energized by a battery *B*, and controlled by a make-and-break *K*. The object of the arrangement was to set up alternate excess and deficiency charges of electrons in the wire *A*, the coil itself being an electron pump for pumping the electrons in and out of the wire, and as these electrons moved up and down through the conductor they set up lines of electric strain all round the aerial, as shown in Fig. 13. Dr. Fleming had on the table a large model, prepared by his pupil, Mr. Glover, to make this point clearer. In the center there was the aerial, and all around it were horseshoe loops, as in Fig. 13, which, of course, only shows those in one plane. In addition, there was a further series of loops outside the first and of a reverse form, showing those which were thrown off from the aerial into space at each reversal of the current. The coil *I*, Fig. 12, charged the wire *A* to such a pressure that the air in the spark-gap broke down under the strain. Roughly, it took 3,000 volts per millimeter, and when this pressure was attained it escaped across the gap, just as steam pressure escaped after lifting the safety valve. The electrons then rushed across the gap like boys out of school when the door was opened. They, however, in consequence of their inertia, soon overran themselves, and then came back, the result being a rapid oscillation across the gap until such time as the air recovered itself and shut the door. Figs. 14 to 19, subjoined, show the formation of the electric waves in the ether round the aerial much more clearly. In Fig. 14 the pressure had just risen to its full; in Fig. 15 it was dropping; in Fig. 16 one set of waves had been thrown off, and the pressure was again rising; in Fig. 17 the first set of waves was clear, and in Fig. 18 the second set had already been formed. Fig. 19 showed the circles of magnetic flux at right angles to the line of the waves. These diagrams illustrated the correct explanation of Marconi's aerial; and in all the accounts which he read of it in only one article by Mr. Taylor in the Electrical Review for 1899 had he found Hertz's conceptions correctly applied.

Now he would pass on to the nature of the operations in detail. These operations, which he had been considering in external space around the aerial, were accompanied by motion of the electrons in the wire like that of air in the organ pipe. He threw upon the screen a moving model, in which the air inside the organ pipe was represented by bright beads; and when this model was worked, the beads were shown to gather together in areas of condensation, separated by areas of rarefaction, and then to separate and gather in intermediate groups. These represented the stationary waves which occur in the organ pipe, and should be understood by everyone. The air is blown through a mouthpiece with a sharp edge, and sets up slight pressure on the inside of the pipe. The air in the pipe is first condensed; then it returns, deflecting the jet outward. The air particles commence their travel backward, and the jet is drawn in, and it is this constant movement which sets up the note in the pipe. In the closed pipe (Fig. 20) the variation of pressure is the greatest at the top, as there, of course, the air particles cannot move outward, while at the mouthpiece there is no change of pressure, as the air is in communication with the atmosphere; but there is a large range of motion as the air moves backward and forward. The dotted curve in the left-hand figure shows the pressure in the closed organ pipe at a particular moment, while the curve on the right-hand figure illustrates the motion of the air in the pipe, the greatest motion occurring where the pressure is least, as already explained. Dr. Fleming illustrated this motion further by means of a well-known appliance, which comprises an organ pipe, a number of gas-jets, and a revolving mirror, and he showed first how it was possible to sound the fundamental note of the pipe, which had a wave-length four times the length of the pipe, and also, by increasing the air pressure, several harmonics of this note. Fig. 21 is an analogous diagram to Fig. 20, but applied to a Marconi aerial. Such an aerial reproduced electrically, the lecturer said, the pneumatic phenomena already explained for the organ pipe. The pressure in the wire rises from the spark-gap upward, being the greatest at the top, while the movement of the electrons in the wire is practically nothing at the top, and is very considerable near the gap. Dr. Fleming said that those w' had been educated merely by studying continuous cu ents would find a difficulty in understanding this, but those who were acquainted with the phenomena of oscillating currents would know that it was quite possible to have currents of very varying magnitude, and even of opposite directions, in a short conductor. He then threw on the screen diagrams of various kinds of Marconi aerials. Fig. 22 shows at the left the simplest form of all; in the center is a quadruple aerial, and at the right a multiple. Fig. 23 shows two other forms, more complex than the preceding ones, the object of these being to gain more radiating power than can be obtained from a single wire. Fig. 24 shows Dr. Fleming's equal periodic radiator, all the wires having the same capacity and inductance, so that they act identically in the formation of electric waves. Unfortunately, the multiplication of wires does not add to the capacity in the same proportion; 100 wires have not 100 times the capacity of one, and they may not have ten times as much.

The lecturer said he would now turn to certain facts about the storage of energy. The purpose of an aerial wire was to store up energy, and the amount which it would contain was given by the following formulæ:

Energy Storage of an Aerial.

C = capacity in microfarads.
V = charging voltage.
S = spark-length in millimeters.
E = energy in joules.
F = energy in foot-pounds.

$$E = \frac{C V^2}{2 \times 10^6}$$

$$F = \frac{3 C V^2}{8 \times 10^6}$$

$$F = \frac{27 C S^2}{8}$$

The capacity of a wire was very small indeed. An aerial wire 100 feet long and 1-10 inch in diameter, had a capacity of about 1-5000 microfarad. It was only possible to charge a certain amount of energy into such a wire, because when the limit was exceeded the spark-gap broke down. Of course the storage could be increased by increasing the length of the gap, but in that case there were no oscillations. If the gap were too long, the electrons did not return into the wire; they merely passed out and stayed out, and there was no oscillation set up; consequently there was a practical limit to the length of the spark-gap. With a pressure of 30,000 volts the stored energy in the aerial was 1-14 foot-pound, and yet that energy was able to make itself felt clearly at a distance of 100 miles. It had been objected to wireless telegraphy that it was extravagant in power; while, as a matter of fact, it used far less power than did ordinary telegraphy. In the Marconi-Braun radiator the energy of the wire had been increased by making a portion of the aerial into a transformer, and by putting the spark-gap in the primary circuit, as shown in Fig. 25. The inductor *I* charged the condenser *C*, in circuit with which was a coil which formed the primary of a transformer, the secondary of which was in the aerial. When an oscillating current was set up in the primary by means of the spent-gap *S*, an enormous voltage was induced in the aerial *A*, and there was a great increase of energy by this method. The two circuits needed to be tuned together in order to get the best results, but this was a matter he would deal with in the fourth lecture.

Dr. Fleming then turned to the subject of the length of the waves thrown off by an aerial, and the length of the aerial itself. When the wave-length was that corresponding to the fundamental of a closed organ pipe, it was four times the length of the aerial—that is, if the wire were 100 feet long, the wave was 400 feet. This condition of affairs was shown by the left-hand diagrams in Figs. 26 and 28. It was possible, however, to obtain harmonics of this length, just as an organ pipe might be made to form a node intermediate between its ends. Fig. 27 represented the harmonics of an open organ pipe. As the top and bottom were both open to the atmosphere, it was clear that at these two points there could be no pressure on them. Four possible conditions were shown in Fig. 27, beginning with a wave-length twice that of the pipe, and finishing with one-half the length of the pipe. Fig. 28 showed the harmonics for the closed organ pipe, which, as has already been explained, was the analogue of the Marconi aerial. In this, of course, there could be no pressure at the bottom, and a pressure anti-node existed always at the top. The left-hand view showed the condition of affairs when the length of the pipe equaled one-quarter the wave-length, and the right-hand view the condition for the first harmonic, in which the length of the pipe was three-quarters of the wave-length. Just as the closed organ pipe could, by proper manipulation, be enabled to give the four notes indicated in Fig. 28, so the Marconi aerial could be made to give different waves, corresponding both to its fundamental and to its harmonics. Dr. Fleming said that few people had ever seen electric waves, but he would attempt to make them visible to his audience. He had a wire of several hundred feet in length, corresponding to a Marconi aerial; as it was not possible to stretch it out straight in the hall, it had been wound into a long vertical spiral. This wire was arranged as a Braun radiator, shown in Fig. 29. Parallel with this spiral coil, and at 2 inches or 3 inches from it, was a vertical naked wire, *E*, which was earthed. When the pressure was created in the aerial, it became so great that sparks would leap across from it to this earthed wire, and over a large portion of its length there was a brush discharge which showed itself in a fine, blue luminous haze; the spark took place only at the top of the spiral, at the part where the pressure was shown to be greatest, according to Fig. 21, while the luminous haze below gradually thinned off as it went down, suggesting the curve set up in Fig. 21. To make it still more evident what was happening, Dr. Fleming held a metal rod near to the aerial; when he placed this metal rod at the upper end, sharp vicious sparks sprang outward from the aerial over 3 inches or 4 inches. As the rod was lowered toward the middle of the aerial, sparks could not be obtained unless the rod was placed much nearer, say, at 2 inches distance; while down at the bottom the two had to almost touch before there would be a spark. There was, however, this difference, that while the upper sparks were blue and thin, those at the bottom were bright and thick, and what are known among electricians as "fat" sparks. That is to say, that while the pressure was great at the top of the aerial, there was very little current to make the leap, while down at the bottom there was ample current once the air insulation had been broken down; but there was comparatively little pressure to do this. Next Dr. Fleming altered the arrangement of the radiator in regard to its inductance and capacity, and so tuned it to a quicker vibration, the first and second arrangements being shown in Figs. 30 and 31 respectively. To do this, he placed the two Leyden jars *L*, *L* in series instead of in parallel, and altered the inductance. Owing to there being some amount of light in the room, the result of this experiment could not be seen quite so clearly as the previous one, but yet it was possible to make out that there were two points of maximum pressure, one at the top of the aerial and one about one-third of the distance from the bottom. This was a most brilliant experiment, and elicited rounds of applause, for it was the first time, as far as we know, that the varying pressure in a continuous conductor has ever been made visible to an audience in this country. The particular apparatus employed was that form arranged by Dr. G. Seibl, and had not before been exhibited in this country.

The Slaby-Arco radiator, said Dr. Fleming, depended for its action on inducing overtones, as already described. If the aerial were of a horseshoe shape, as shown to the left in Fig. 32, it is evident that there would be no waves thrown out into space, because the effect of the one arm of the radiator would be to annul the effect of the other; but by making one of the arms multiplex, as shown on the right-hand side of the figure, A'_2, it was possible to produce harmonics in that portion of the apparatus, and thus to throw out into space waves of a corresponding length. This occurred because there was greater inductance in this part of the circuit. That might be explained by means of the diagram, Fig. 33. If a long spiral wire were suspended by fine threads from a beam, and were then moved backward and forward, the coils would all move together; but if a weight were applied to one end of them, as shown, and the pressure applied at the other, the spiral would fall into waves of alternating compression and expansion, one end of it moving in one direction, and one in the other, at a given instant. The result would be as shown in Fig. 34, in which it would be seen that the electrons in the right-hand figure were both moving upward, as if there were a single wire, as in the Marconi system. In an organ pipe it was very difficult to get a tone without producing some of the harmonics with it; and, indeed, the makers generally arranged that there should be some harmonic tones, as the fundamental itself was somewhat flat and monotonous; the harmonics lent brilliancy to the instrument. On the other hand, it was not easy in an aerial to get harmonics at all; it was quite easy to get the fundamental, but not the others. They found at Poldhu, in their great aerial there, that the pressure at the top sometimes rose so high that sparks 7 feet long would be given off. Fig. 35 showed the arrangement adopted to gain this pressure.

NEW MEXICO AND COLORADO TEMPERATURES.

ACCORDING to the Santa Fé New Mexican, the highest temperature ever recorded at Denver and in Colorado was 105 degrees above zero. The coldest temperature ever recorded in Denver was 29 degrees below zero, and at outside Colorado points 39 degrees below zero. The highest temperature on record in Santa Fé is 97 above zero and the lowest 13 degrees below zero. The Weather Bureau records also say that Santa Fé has 10 per cent more sunshine per year than Denver or Colorado Springs. In other words, Santa Fé weather is 16 to 25 degrees milder in winter, 8 degrees cooler in summer, and more sunshiny the year round than the weather of Denver, Colorado Springs, and other health resorts of the Centennial State.

"MAISINE," NEW PRODUCT OF MAIZE.

MESSRS. E. DONARD AND H. LABBÉ have succeeded in obtaining an albuminoid substance from maize, somewhat resembling gluten, which has some interesting properties. These are described in a paper read before the Academie des Sciences. Up to the present the gluten of wheat seems to be the only one of the albuminoid substances of cereals that has been well studied. Ritthausen considers wheat gluten to be a complex product formed of three proteid substances, gluten-fibrine or glutenine, gliadine and mucedine. These differ especially from each other by their unequal solubility in ethyl alcohol at different concentrations, and they may be thus separated. The same chemist has obtained from maize a mixture of albuminoid matters which resembles wheat gluten in appearance, but differs completely from it as regards its chemical properties. The authors have found a method of extracting the proteid substances of maize, not in the viscous form which Ritthausen obtained, but in a state of powder and quite pure. A part of these proteid substances are soluble in iso-amylic alcohol, while the gluten of wheat is insoluble in the same.

To obtain the product the maize is reduced to flour, then dried and deprived of its oil by treating with crystallizable benzine. It is then treated with hot amylic alcohol and after eight hours the amylic solution is precipitated by an excess of benzine (three times the volume). The albuminoid matter is nearly insoluble in this mixture and forms a woolly precipitate. The latter is then washed and dried *in vacuo*. This substance, which the authors call "maisine," as they have not found it in other cereals or vegetables, has the aspect of a white powder, extremely fine and light. Its composition is C 54.72; H 7.63; N 15.9; S 0.80; ash 0.06. From the weight of the sulphur they deduct a minimum weight of the molecule of 4,000, which corresponds to the composition $C_{184} H_{300} N_{46} O_{31} S$. Maisine is insoluble in cold or hot water and in saline solutions, but dissolves in methyl or ethyl alcohol and acetone; its solubility is much greater when hot and it precipitates on cooling. It is also precipitated from these solutions by ether, benzine and hydrocarbons, but then in a state of hydrate which transforms it to a sticky matter which adheres to the glass and gives on drying a yellow translucent and horn-like substance. It is also soluble in small proportion in boiling amyl acetate and deposits a white powder when cold. Although insoluble in dilute acids such as 5 per cent acetic acid, it develops a special odor when boiled with the latter. Alkalies dissolve it easily, for instance a 1-100 soda solution, or even as low as 1-2000. In the higher alcohols, propylic or isobutylic, it dissolves as in amyl alcohol. The latter only dissolves traces when cold, but when hot the quantity

reaches 11 per cent of the weight. The authors find that the proportion of maisine contained in maize is about 4 or 4.5 per cent.

TRADE NOTES AND RECIPES.

Alloys for Decorating Gold Ware.—Alloys showing various colors are produced by the following receipts. Such alloys are frequently employed for providing gold articles of certain degrees of fineness with special ornaments. The alloy contains:

	Gold.	Silver	Copper.	Steel.	Cadmium.
1.	2.6	1.0	....	....	....
2.	75.0	16.6	....	....	8.4
3.	74.6	11.4	9.7	....	4.3
4.	75.0	12.6	....	....	12.5
5	1.0	2.0	....	....	....
6.	4.0	3.0	1.0	....	....
7.	14.7	7.0	6.0	....	....
8.	14.7	9.0	4.0	....	....
9.	3.0	1.0	1.0	....	....
10.	10.0	1.0	4.0	....	....
11.	1.0	....	1.0	....	....
12.	1.0	....	2.0	....	....
13.	30.0	3.0	....	2.0	....
14.	4.0	....	....	1.0	....
15.	29.0	11.0	....	....	....
16.	1.3	....	....	1.0	....

Nos. 1, 2, 3 and 4 are green gold, No. 5 is pale yellow, Nos. 6, 7, 8 bright yellow, Nos. 9 and 10 pale red, Nos. 11 and 12 bright red, Nos. 13, 14 and 15 gray, while No. 16 exhibits a bluish tint. The finished gold ware before being put upon the market is subjected to a special treatment, consisting either in the simple pickling or in the so-called coloring, which operation is conducted especially with alloys of low degree of fineness, the object being to give the articles a superficial layer of pure gold.—Metallarbeiter.

To Clean Buildings, etc. from Vegetable Growth.—To remove the disfiguring moss and lichen from stone and masonry, the latter should be given a coating of water in which 1 per cent of carbolic acid has been dissolved. After a few hours the plants can be washed off with water.—Maler Zeitung.

Influence of the Concentration and Temperature of the Developer.—As regards the influence of the concentration and temperature of the developer, the various degrees of concentration and temperature gave the following results according to Huebl:

Concentration.

Iron oxalate	Developing period.
3 per cent.	20 seconds.
2 per cent.	24 seconds.
1 per cent.	47 seconds.
0.5 per cent.	85 seconds.

Temperature.

Glycine	22 degrees C.	60 seconds.
Glycine	17 degrees C.	104 seconds.
Glycine	12 degrees C.	138 seconds.
Amidol	16 degrees C.	22 seconds.
Amidol,	8 degrees C.	48 seconds.
Amidol	1 degree C.	70 seconds.

—Deutsche Photographen Zeitung.

Gold and Silver Pressed Work on Velvet.—For the production of pressed work of gold and silver on silk-velvet and cotton-velvet in the piece, the velvet receives a bath of fresh brown-beer (a cheap grade of beer) or the pile side of the velvet is coated with the beer by means of a sponge. To restore the pliancy of the velvet and the softness of the nap, the piece is passed through the breaking machine, then through the brushing apparatus and next receives on the back a size-dressing as a foundation for the gluing agent in the pile absorbed with the beer, so that the adhesive agents of the right and wrong sides of the velvet will combine in a durable manner when pressed under the hot roller. The piece thus prepared is rolled up and moves slowly under the hot engraved cylinder of the goffering machine, powdered gold, silver or pigment being sprinkled on by the roller. After cooling the superfluous powder which has not been pressed in is removed by means of a brush.—Der Stein der Weisen.

Tooth Powders.—Alkaline Tooth Powder.—Precipitated calcium carbonate 60 grammes, quinine sulphate 2 grammes, saponin 0.1 gramme, saccharin 0.1 gramme, carmine as required, oil of peppermint 20 drops.

Acid Tooth Powder.—Boracic acid 100 grammes, powdered starch 50 grammes, quinine hydrochlorate 10 grammes, saccharine 1 gramme, vanillin (dissolved in alcohol) 1.5 gramme.

Neutral Tooth Powder.—Potassium chlorate 200 grammes, starch 200 grammes, carmine lake 40 grammes, saccharine (in alcoholic solution) 1 gramme, vanillin (dissolved in alcohol) 1 gramme.—Revue Médico-Pharmaceutique.

Petroleum Hair Washes.—The Pharmaceutische Zeitung of Berlin gives some French receipts for the production of petroleum hair washes:

1. Petrole Hase.—Deodorized pale petroleum 10, citronella oil 10, castor oil 5, spirit of wine, 90 per cent, 50, water 75.

2. Petrolin.—Quinine sulphate 0, acetic acid 4, tincture of cantharides 30, tincture of quinine 3, spirit of rosemary 60, balm water 90, barium 120, spirit of wine 150, water 1,000.

3. Very pure petroleum 1 part, almond oil 2 parts.

As a Substitute for Gum Tragacanth which is indispensable for various industrial purposes, C. Boschon proposes a mixture of wheat starch 20 parts by weight, pale joiner's glue 6 parts and glycerine 2 parts. This mixture is boiled in water; it is said to equal gum tragacanth in effect. An elastic and quite transparent colorless finish may also be prepared from a mixture of starch 6 parts and glycerine 3 parts.—Färber und Wäscher.

Tooth Cement.—

Paraformaldehyde	1
Zinc oxide	100

Add creosote and formaldehyde, as much as is necessary to form a mixture.—Pharmaceutische Post.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Surtax on Goods Indirectly Imported into France.—Vexatious correspondence and loss of money have recently resulted in a number of cases, because of unfamiliarity, on the part of United States shippers to France, with the French regulations respecting merchandise transshipped in some European port before arriving in the port of destination. In some instances, merchandise has been forwarded under what the consignors deemed to be a through bill of lading, the possession of which they vainly presumed would protect them against the imposition of the French surtax which is applicable in the case of importations from a European country of products of extra-European origin. The exemptions from this surtax are: Quinine bark; Australian, South African, and Indian wool; Indian cotton, jute, cacao fiber, and vegetable fiber generally, with the exception of cotton; tobacco; and Ceylon plumbago. It will be observed that none of these exemptions cover merchandise of American origin. The surtax ranges from 1.80 francs (34 cents) to 60 francs ($11.58) per 100 kilogrammes (220 pounds) in about forty specified cases, and is 3.60 francs (69 cents) per 220 pounds in all nonspecified cases. In order that there may be no misunderstanding about the matter, I have procured from the collector of customs at this port an official letter, in which he says:

"Replying to your inquiry of the 6th instant, I have to say that, except in cases of superior force or acts of God, which do not constitute an interruption to direct transportation, merchandise transshipped in the course of its journey by sea is regarded as having arrived from the place where such transshipment has occurred. It results from this that the surtax is applicable to products of extra-European origin brought into France by a ship which has received them in a European port, whatever may have been the commercial reasons and particulars respecting the transshipment.

"This surtax is applicable to nearly all classes of merchandise, and the exceptions to the rule are very rare indeed. These exceptions in general arise from geographical or economic considerations, and it suffices to cite a few examples to design their character. Thus, for example, it is possible to import by way of Denmark the products of Iceland and the Faroe Islands; from European Russia, the products of Asiatic Russia; from Constantinople and the European ports of Turkey upon the Black Sea, the products of the Asiatic possessions of the Ottoman Empire; from Spain, the products of the Canary Islands and of the Spanish possessions of the Morocco coast, etc."

As American shippers are obliged to pay the maximum tariff of France, except in a limited number of cases covered by the commercial convention with the United States, signed on May 30, 1898,* the imposition of a surtax makes the transaction of business practically impossible, and shippers should guard against the possibility of the application of this surtax by forwarding their goods on board steamers sailing directly from American to French ports.—Robert P. Skinner, Consul-General at Marseilles.

American and Russian Petroleum in Germany.—In the 1902 report of the chemical examination bureau of Breslau, it is stated that Roumanian petroleum, which had at one time been looked upon as a promising factor in the German markets, has almost disappeared, as well as the Galician product. The Galician wells, it is said, are no longer as productive as formerly. This leaves the field open to the efforts of the American and the Russian companies. It is stated to be in the interest of Germany to see that there is no coalition between these two, which can be prevented only by increasing the demand for the Russian product. The German buyer, however, is said to look upon the Russian oil with disfavor. The German authorities have for years been increasing their orders to the Russian company, asserting that this oil is cheaper and of a better quality than the American; but private consumers care nothing about the origin of the oil they use, and the merchants in general continue in their refusal to purchase Russian petroleum. Nevertheless, the report shows that this oil has won considerable ground since 1898.

Lately, there have been renewed efforts to obtain a larger market for Roumanian oil, which have been greatly aided by the statements of German chemists that this oil has proved to be more economical than the American, and that it may be used in lamps constructed for American oil.—Ernest A. Man, Consul at Breslau.

German Meat-Inspection Fees.—Consul J. E. Kehl transmits from Stettin, May 29, 1903, translation of a newspaper article in regard to the burdensome results of the new meat-inspection act, which reads, in part:

"Importers have informed us that at certain places the inspection and examination lasts three or four days. At one of the Berlin custom houses, there recently arrived from Budapest 42 barrels of salted guts, for which an inspection fee of 178 marks ($42.36) was paid. The fees practically prohibit importation, and the people who eat sausage are subjected to a new indirect tax."

Bridge Over the Arimao River, Cuba.—The largest bridge yet constructed in Cuba was completed and opened to the public on May 15. It is 20 miles from Cienfuegos, on the road to the Manicaragua Valley, the tobacco-growing belt of Santa Clara Province.

The bridge spans the Arimao River and is 454 feet in length, with a width of 17 feet. It has two piers and two abutments of hydraulic concrete; Atlas cement was used, and granite for stone capping. The piers are 35 feet above the normal stage of water, and the flooring is of native hard woods—mahogany, black jucaro, and sabicu. It is a steel bridge, of the Pratt riveted system, made by the American Bridge Company, of New York; 11,000 rivets were driven in Cuba.

The contract was let February 13, 1902, at a cost of $50,000. The work of construction was somewhat retarded by floods, which twice carried away the supporting works.

Manicaragua Valley is 36 miles northeast of Cienfuegos, but there will soon be a well-graded and macadamized highway covering the greater part of the distance; and this, in connection with the bridge, opens up to settlement one of the most fertile regions of the island, as the Manicaragua tobacco is said to excel that of Vuelta Abajo in aroma.

The completion of this bridge not only marks an epoch in the development of this section of the island, but is also highly appreciated by those having occasion to use it, because traffic was sometimes suspended for thirty days before construction on account of floods in the Arimao.—Max J. Baehr, Consul at Cienfuegos.

Olive Oil in Italy.—Consul-General H. de Castro sends from Rome, May 19, 1903, a letter from the president of the United Chambers of Commerce of Italy, which says, in part:

"I take the liberty of calling attention to a report from a consul in Spain which appeared in No. 1589 of the Advance Sheets of Consular Reports on March 9 last. It is asserted therein that Italian oil exporters, in the years of short crops, import oil from Spain, mix it with American oil, and export said mixture to the United States as an Italian product. Considering that foreign oil is charged in Italy an import duty of 6 francs per 100 kilogrammes ($1.16 per 220 pounds), and that no drawback is allowed for re-exportation, it is difficult to perceive the advantage Italian commerce could derive from such a process. As far as this year's crop is concerned, I must observe that, although it is inferior to the average of the last four years, it has exceeded the Spanish crop and it would thus seem more rational for Spanish exporters to come to Italy for their requirements.

"It is a fact that Italy buys at irregular times, when her crops run short, some olive oil from Spain—this, however, in small proportion compared with her own exportation. As the oil so imported is subjected to duty and is generally lower in price than the Italian product, said imported oil must necessarily be used for home consumption. It is natural that Italian producers should export the finer product in order to enable them to compete with the producers of other countries."

The consul-general adds that he has personally studied the oil industry in Italy and has never found that the product was adulterated for exportation purposes.

German Electrical Goods for Russia.—Consul B. H. Warner sends the following from Leipzig, May 28, 1903:

German electrical interests are petitioning the government officials to arrange in making a new commercial treaty with Russia for lower duties upon German electrical supplies. At the present time about 20,000,000 marks' ($4,760,000) worth of electrical goods are exported to Russia from Germany annually, and the amount is increasing from year to year.

Coal Prices in New South Wales.—Consul F. W. Goding reports from Newcastle, May 2, 1903, that a majority of the coal-mining companies in the district have agreed that from May 15 the price of coal shall be 10s. ($2.43) per ton (a reduction of 1s., or 24 cents), and, according to the provision of the sliding scale, the hewing rate is to be reduced from 4s. ($1) to 3s. 10d. (92 cents) per ton. It is significant, he adds, that the four collieries having the greatest output refuse to make the reduction.

German Inquiry for Red Zinc Ore.—Consul E. A. Man, of Breslau, May 19, 1903, reports that he has an inquiry from a prominent local firm dealing in metals, ores, etc., for large quantities of red zinc ore, regardless of whether it is calamine, galmei, or blende, or what percentage of zinc it may contain, the important requirement being that it shall possess a purely natural red coloring. Anyone who can furnish such ore is asked to communicate with the consulate.

Sicilian Lemon Crop.—Consul Alexander Heingartner reports from Catania, May 16, 1903:

The summer lemon crop in this consular district promises well. The fruit is of very good quality, although, owing to the dry winter, dirty in appearance. The crop is about the same as last year; the amount for export is estimated at 140,000 boxes (300 in a box); prices, 10 to 12 lire ($1.93 to $2.23), according to quality. Freight rates to New York, per box, are 1s. 3d. (30.4 cents).

German Sugar in England.—Consul B. H. Warner reports from Leipzig, May 27, 1903:

There has been a decided decrease during the last few months in the quantity of beet sugar exported from Germany to England, the loss amounting for the first quarter of 1903 to almost 63,000 long tons in raw sugar alone. England has, it is true, a considerable stock from 1902; but another reason for the decrease is that larger quantities of cane sugar have been imported from the English colonies. Cane sugar is also being bought from Cuba, a thing which has not been done for twenty-five years.

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No. 1674. June 17.—* Surtax on Goods Indirectly Imported into France—* American and Russian Petroleum in Germany—* Transit Dues at Lourenço Marques—* Wheat Prospects in Russia—* Sicilian Lemon Crop—New Iron Mill in Germany.

No. 1675. June 18.—United States Trade in British India—* Bridge over the Arimao River, Cuba—Fishing in Algeria—* German Meat Inspection Fees—* German Electrical Goods for Russia.

No. 1676. June 19.—Pollak-Virag Rapid Telegraph in Germany—Proposed Tariff Changes in France—* Olive Oil in Italy—* Coal Mining in Poland in 1902—Powerful Steam Dynamo in Germany.

No. 1677. June 20.—Iron in the Sudan—* German Sugar in England—Regulations for Electric Cars and Automobiles in Leipzig—* German Sailcloth in South America—* Copper Production in Hungary.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

* See Special Consular Reports, Tariffs of Foreign Countries, Part I, p. 222.

SELECTED FORMULÆ.

Medicinal Soap.—Alum Soap.—Saponify 20 kilos of coconut oil with 10 kilos of caustic soda lye of 38 degs. Upon complete saponification stir in 1 kilo of alum dissolved in hot water.

Benzoin Soap.—Coconut oil 20 kilos, caustic soda lye, 38 degs., 10 kilos, tincture of benzoin ½ kilo.

Ichthyolic Soap.—Coconut oil 20 kilos, caustic soda lye, 38 degs., 10 kilos, cade oil 6 kilos, ichthyol 3 kilos.

Iodine Soap.—Saponify 20 kilos of coconut oil with 10 kilos of caustic soda lye of 38 degs.; then add 3 kilos of potassium iodide dissolved in 4 kilos of water.

Camphor Soap.—Coconut oil 20 kilos, caustic soda lye, 38 degs., 10 kilos, camphor 2 kilos dissolved in 3 kilos of spirit.

Carbolic Glycerine Soap.—Heat 25 kilos of tallow and 25 kilos of coconut oil to 167 deg. F., likewise 25 kilos of caustic soda lye of 38 degs., to the same temperature; then add carbolic acid, chemically pure, 10 kilos, glycerine 10 kilos and spirit, 96 per cent, 12.5 kilos.

Creoline Soap.—Saponify 20 kilos of coconut oil with 10 kilos of caustic soda lye of 38 degs., and admix by stirring 2 kilos of creoline.

Creosote Soap.—Coconut oil 20 kilos, caustic soda lye, 38 degs., 10 kilos, creosote 2 kilos.

Kummerfeldt's Chilblain Soap.—Saponify 20 kilos of coconut oil with 9 kilos of caustic soda lye of 38 degs., and 1 kilo of caustic potash lye of 38 degs. Into this stir ½ kilo of powdered flowers of sulphur, add ½ kilo of powdered camphor dissolved in 1 kilo of 96 per cent spirit and stir until saponification results.

Salicylic Acid Soap.—Coconut oil 20 kilos, caustic soda lye, 38 degs., 10 kilos, crystallized salicylic acid 60 grammes, rosemary oil 60 grammes, medea oil 20 grammes.

Sulphur Soap.—Coconut oil 20 kilos, caustic soda lye, 38 degs., 10 kilos, flowers of sulphur 5 kilos.

Milk of Sulphur Soap.—Coconut oil 20 kilos, caustic soda lye, 38 degs., 10 kilos, flowers of sulphur 2 kilos; rub up in a mortar with 1 kilo of glycerine; cinnamon oil 60 grammes, bergamot oil 50 grammes, brimstone yellow 5 grammes.

Storax Soap.—Coconut oil 20 kilos, caustic soda lye, 38 degs., 10 kilos, stirring in 5 kilos of storax.

Tannin Soap.—Coconut oil 20 kilos, caustic soda lye, 38 degs., 10 kilos, tannin 3 kilos, dissolved in boiling water; light brown.

Tannin Balsam Soap.—Coconut oil 20 kilos, caustic soda lye, 38 degs., 10 kilos, tannin 3 kilos dissolved in 2 kilos of spirit, styrax liq. 1.5 kilo, Peru balsam 80 grammes; chocolate brown.

Tar-Sulphur Soap.—Coconut oil 20 kilos and coal tar 3 kilos, dissolve; stir in 2 kilos of flowers of sulphur and saponify with 11 kilos of caustic soda lye of 38 degs.

Vaseline Soap.—Coconut oil 20 kilos, vaseline 3 kilos, caustic soda lye of 38 degs., 10 kilos; sultana-yellow 10 grammes, stirred in 0.5 kilo of water.

Vaseline Tar Soap.—Coconut oil 20 kilos, tar 3 kilos, water 1 kilo, caustic soda lye of 38 degs., 10 kilos, vaseline 3 kilos.

Juniper Tar Soap.—Coconut oil 20 kilos, caustic soda lye 38 degs., 10 kilos, juniper tar 4 kilos.—Translated from Parfumerie.

[The medicinal admixtures seem rather large in some cases.—Translator.]

Liquid Insecticides.—

1

Paraffin	10 parts
Benzine	70 parts
Balsam of copaiba	5 parts

2

Carbolic acid	5 parts
Ether	50 parts
Benzine	150 parts

3

Naphthalin	12 ounces
Benzine	2 gallons

Any of these mixtures may be tinted with anilin dye or alkanet root.

The following are from Hager's "Manuale" and contain no benzine:

1

Concentrated vinegar	6 parts
Oil of cloves	2 parts
Oleo-balsamic mixture	25 parts
Rectified spirit	100 parts

2

Tartaric acid	5 parts
Cologne water	20 parts
Rectified spirit	20 parts

Apply to places infested by the pests. Mixtures containing benzine should not be used in a room with a lighted candle or near any flame.—Pharm. Era.

Mahogany Stain for Wood.—Rub the surface of the wood with a solution of nitrous acid, and then apply, with a brush, the following:

Dragon's blood	1 ounce
Sodium carbonate	6 drachms
Alcohol	20 ounces

Filter just before using.—Pharm. Era.

Celluloid Lacquer.—Dissolve uncolored celluloid in a mixture of strong alcohol and ether. The celluloid first swells up in the solvent, and after vigorous shaking the bottle is allowed to stand quietly for the undissolved portion to settle, when the clear, supernatant fluid is poured off. The latter may be immediately used; it yields a colorless glossy lacquer, or may be colored, as desired, with aniline colors.—Pharm. Era.

To Increase the Toughness, Density and Tenacity of Aluminium.—For the purpose of improving the technological qualities of aluminium, without increasing its specific gravity, the aluminium is given, according to a patented process of W. Ruebel, of Berlin, an admixture of 4 to 7 per cent of phosphorus, whereby the density, tenacity and especially the toughness are said to be enhanced. The product is said to be highly suitable as a substitute for braziery, yielding a sharp casting with a shrinkage of 1 to 1½ per cent at most. It can be soldered and does not easily oxidize.—Der Metallarbeiter.

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